PATENT ABSTRACTS OF JAPAN

(11)Publication number : 08-220438
(43)Date of publication of application : 30.08.1996

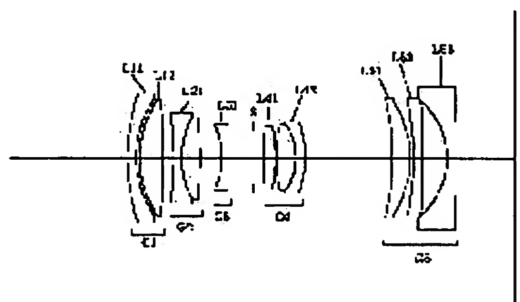
(51)Int.Cl. G02B 15/20

(21)Application number : 07-053578
(22)Date of filing : 17.02.1995

(71)Applicant : NIKON CORP
(72)Inventor : OTAKE MOTOYUKI
SUZUKI KENZABURO

(54) ZOOM LENS FOCUSABLE AT SHORT DISTANCE

(57)Abstract:
PURPOSE: To provide a zoom lens which is focusable at a short distance, allows focusing att a small moving quantity and has excellent imaging performance.
CONSTITUTION: This zoom lens which is focusable at the short distance has at least two lens groups which are arranged adjacently to each other and have a negative refracting power. The focusing to the short distance object is executed by moving the lens group Ga movable att the time of variable magnification of the two lens groups along the optical axis. The zoom lens is so constituted as to satisfy the conditions $(\beta a-\beta 2-1)-2<0.8$, $\beta a/\beta b>0$. When the use magnification of the lens group Ga at a telephoto end in a state of infinitive focusing is defined as βa and the use magnification of the lens group Ga at a wide angle end in a state of infinitive focusing is defined as βb.



LEGAL STATUS

[Date of request for examination]	18.01.2002
[Date of sending the examiner's decision of rejection]	28.11.2003
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] In a zoom lens which was equipped with two lens groups which adjoin mutually, are arranged [both] and have negative refractive power at least and in which a short-distance focus is possible On the occasion of variable power, move a movable lens group Ga in accordance with an optical axis between said two lens groups, and a focus to a short-distance body is performed. When an operating scale factor in a tele edge in an infinite distance focus condition of said lens group Ga is set to betaa and an operating scale factor in a wide angle edge in an infinite distance focus condition of said lens group Ga is set to betab, A zoom lens which is characterized by satisfying conditions of (beta a-beta a-1)-2<0.8beta a/beta b> 0 and in which a short-distance focus is possible.
[Claim 2] A zoom lens which is characterized by satisfying conditions of 0.12<|fa|/(fw-ft)1/2 <0.6 when a focal distance of said lens group Ga is set to fa, a focal distance of the whole lens system in a wide angle edge is set to fw and a focal distance of the whole lens system in a tele edge is set to ft and in which a short-distance focus according to claim 1 is possible.
[Claim 3] It is the zoom lens which is characterized by arranging most the 1st lens group G1 which has positive refractive power at a body side, and for said two lens groups adjoining an image side of said 1st lens group G1, and arranging them and in which a short-distance focus according to claim 1 or 2 is possible.
[Claim 4] A zoom lens in which a short-distance focus given in claim 1 characterized by satisfying conditions of 0.3<fL1/fL 2< 5.0 thru/or any 1 term of 3 is possible when a focal distance of a lens group by the side of a body is set to fL1 between said two lens groups and a focal distance of a lens group by the side of an image is set to fL2 between said two lens groups.

[Claim 5] A zoom lens in which a short-distance focus given in claim 1 characterized by satisfying conditions of nuGa>35nGa>1.60 thru/or any 1 term of 4 is possible when the greatest value is set to nuGa among the Abbe numbers of all negative lens components contained in said lens group Ga and the greatest value is set to nGa among refractive indexes of all negative lens components contained in said lens group Ga.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to a zoom lens applicable also to the bright zoom lens especially whose aperture ratio is about 2.8 about the zoom lens in which a short-distance focus is possible.
[0002]
[Description of the Prior Art] As orientation in the latest camera, two points, the cameras in which ** automatic focus is possible are increasing in number [that a zoom lens is becoming in use / ** taking lens / and], are mentioned.
[0003] The various zoom types which attained raise in variable power and high performance-ization have been proposed as a zoom lens becomes in use. Moreover, the zoom type which attained high variable power-ization by advance of lens-barrel technology in recent years etc. using the so-called multi-group zoom lens constituted by the three or more-group moving lens group is proposed variously. Moreover, with the camera in which an automatic focus is possible, improvement in the speed of focusing (focus) actuation is progressing. And various methods are proposed also about the focusing method in a multi-group zoom lens with improvement in the speed of focusing actuation.
[0004]
[Problem(s) to be Solved by the Invention] Generally, in order to attain improvement in the speed of focusing actuation, being required of a focusing glass group (lens group which moves in accordance with an optical axis at the time of focusing) is making small the workload at the time of focusing (= weight x movement magnitude). However, in the conventional zoom lens, there was un-arranging [that the workload at the time of focusing was not sufficiently small].
[0005] This invention is made in view of the above-mentioned technical problem, and aims at offering the zoom lens in which focusing is possible at small movement magnitude, and the short-distance focus which was excellent in the image formation engine performance is possible.

[0006]
[Means for Solving the Problem] In order to solve said technical problem, it sets to this invention. In a zoom lens which was equipped with two lens groups which adjoin mutually, are arranged [both] and have negative refractive power at least and in which a short-distance focus is possible On the occasion of variable power, move the movable lens group Ga in accordance with an optical axis between said two lens groups, and a focus to a short-distance body is performed. When an operating scale factor in a tele edge in an infinite distance focus condition of said lens group Ga is set to betaa and an operating scale factor in a wide angle edge in an infinite distance focus condition of said lens group Ga is set to betab, A zoom lens which is characterized by satisfying conditions of (beta a-beta a-1)-2<0.8beta a/beta b> 0 and in which a short-distance focus is possible is offered.
[0007] When according to the desirable mode of this invention a focal distance of said lens group Ga is set to fa, a focal distance of the whole lens system in a wide angle edge is set to fw and a focal distance of the whole lens system in a tele edge is set to ft, conditions of 0.12<|fa|/(fw-ft)

1/2 <0.6 are satisfied.
[0008]
[Function] First, the generalities about the so-called multi-group zoom lens constituted by the three or more-group moving lens group are described. In a multi-group zoom lens, since whenever [option] increases into the zooming orbit of each lens group which faces the variable power from a wide angle edge to a tele edge, the flexibility on aberration amendment increases. Moreover, since the lens group which bears variable power increases, it becomes easy to carry out the equation of the variable power burden of each lens group. In this way, it becomes possible to attain high performance-ization, attaining high variable power-ization. In addition, although there were also problems, such as complication of the lens-barrel structure accompanying the increment for moving part, it is conquered to some extent by advance of lens-barrel technology in recent years.
[0009] Next, focusing in a multi-group zoom lens is described. Generally, being required of a focusing glass group are that there is little focusing movement magnitude and that the weight of a focusing glass group is small as mentioned above. This can be tied to the miniaturization of a lens system, so that there is little focusing movement magnitude, and it is because simplification of the drive of a lens can be attained, so that the weight of a focusing glass group is small.
[0010] Before, when performing the focus to a short-distance body in a multi-group zoom lens, various proposals are made about the following three methods.
(A) 1 group delivery method (B) IF (inner focus) method (C) RF (rear focus) method [0011] Before, with 4 group zoom lens right positive in positive/negative, 1 group delivery method of (A) is used for order for example, from a body side. However, since the 1st lens group separates from the image surface most and is arranged, its diameter of a lens is large. Consequently, the 1st lens group is seldom suitable for the focusing glass group. Moreover, the example which is made to move the 2nd lens group of immobilization among variable power to JP,5-224123,A by these people, and performs focusing of the inner focus method of (B) to it in 5 group zoom lens of positive/negative negative positive/negative sequentially from a body side is indicated. However, since the 2nd lens group is immobilization among variable power, the 2nd lens group cannot be made to contribute to a variable power operation positively, and it cannot be said that it is enough in respect of high-performance-izing.
[0012] Furthermore, the example which is made to move the 4th lens group of 4 group zoom lens of positive/negative positive/negative to JP,61-50112,A sequentially from a body side, and performs focusing of the rear focus method of (C) to it is indicated. However, since the diameter of a lens is large, the 4th lens group is seldom suitable for the focusing glass group.
[0013] Here, migration of the focusing glass group at the time of moving one lens group and performing focusing is described. If the focusing glass group Gf is moved so that the location of the object point by the 1st lens group G1 thru/or the focusing glass group Gf to the lens group Gh arranged at the image side of the focusing glass group Gf may become fixed when the location of a photographic subject moves at a short distance from a long distance, a short-distance focus can be performed. Under the present circumstances, the conditions which make small movement magnitude delta of the focusing glass group Gf are explained using a thin lens system.
[0014] First, in order to make regularity the location of the object point to the lens group Gh when the location of the object point to the focusing glass group Gf moves only delta as shown in drawing 1 , only delta shall move the lens group Gf. In this case, if the image formation scale factor of the lens group Gf is set to beta, the movement magnitude delta of the focusing glass group Gf will be given with the following formula (a).
delta= [beta2/(beta2-1)] -delta (a)
[0015] (a) The value of k is beta 2 in a formula when k=beta 2/(beta2-1). It comes to express with the following formula (b) and (c) depending on a value.
k>=1 (beta2 > 1) (b)
k< 0 (beta2 <1) (c)
[0016] Therefore, in order to make small magnitude of the movement magnitude delta of the lens group Gf, to be (c), k is brought as much as possible close to 0, namely, it is required [k is

brought as much as possible close 1, namely, / it is required to bring 1/beta close to 0, and] in (b), to bring beta close to 0.

[0017] In the zoom lens which has at least two lens groups which adjoin mutually, are arranged [both] and have negative refractive power in this invention based on the above consideration While bringing the inverse number of the operating scale factor of the lens group arranged between these two lens groups at the body side close to 0 By bringing the operating scale factor of the lens group arranged at the image side close to 0, even if it moves which lens group between two above-mentioned lens groups at the time of focusing, the focusing movement magnitude can be made small. In this invention, in order that drawing may tie equalization of the burden of the variable power of each lens group to high variable power-ization, the movable lens group Ga is moved between two lens groups at the time of focusing at the time of variable power.

[0018] This invention is made based on the above technological backgrounds, and in a zoom lens with which both two lens groups arranged adjacently have negative refractive power and in which a short-distance focus is possible, it aims at solution of the above-mentioned technical problem by fulfilling predetermined conditions while it moves the movable lens group Ga on the occasion of variable power between two lens groups and performs focusing to a short-distance body.

[0019] Hereafter, the monograph affair type of this invention is explained. It is satisfied with the zoom lens of this invention of the following conditional expression (1) and (2).

(beta a-beta a-1) -2<0.8 (1)

beta a/beta b> 0 (2)

Scale-factor [operating] betab [in / here / the tele edge in the infinite distance focus condition of the betaa:lens group Ga]: The operating scale factor in the wide angle edge in the infinite distance focus condition of the lens group Ga [0020] Conditional expression (1) is conditional expression which specifies the operating scale factor in the tele edge of the focusing glass group Ga. As mentioned above, the focusing movement magnitude (movement magnitude which faces focusing) delta of the lens group Ga is expressed with a formula (a), and can make small focusing movement magnitude delta of the lens group Ga by making magnitude of k small.

[0021] In addition, conditional expression (1) is 2 (k/beta) by deforming. It is expressed. That is, in conditional expression (1), the feature of this invention which makes small focusing movement magnitude delta of the lens group Ga is emphasized by making magnitude of k small by carrying out the square of the ratio of k and beta. When it exceeds the upper limit of conditional expression (1), the focusing movement magnitude of the lens group Ga will become large. In addition, in this invention, in order to stop the focusing movement magnitude of the lens group Ga still smaller, it is desirable to set the upper limit of conditional expression (1) to 0.5.

[0022] As mentioned above, in the case of beta2 >1, if 1/beta is brought close to 0, focusing can be performed with small movement magnitude. However, if the location used as 1/beta= 0 exists in the variable power from a wide angle edge to a tele edge, since k will decrease from a wide angle edge up to the location of 1/beta= 0 and k will increase from the location of 1/beta= 0 to a tele edge, control of the lens group Ga will become difficult. Moreover, in the case of beta2 <1, if beta is brought close to 0, focusing can be performed with small movement magnitude. However, if the location used as beta= 0 exists in the variable power from a wide angle edge to a tele edge, since k will decrease from a wide angle edge up to the location of beta= 0 and k will increase from the location of beta= 0 to a tele edge, control of the lens group Ga will become difficult.

[0023] Conditional expression (2) has specified the suitable range about the ratio of operating scale-factor betaa of the lens group Ga in a tele edge, and operating scale-factor betab of the lens group Ga in a wide angle edge. When less than the lower limit of conditional expression (2), 1/beta or beta will include the location set to 0 in the variable power from a wide angle edge to a tele edge. For this reason, as mentioned above, control of the lens group Ga will become difficult. Especially, the amount of deliveries to the same photography distance decreases once, and increases from the middle as it carries out variable power to a tele edge from a wide angle edge. For this reason, it will become difficult to carry out position control of the focusing glass group.

[0024] Moreover, in this invention, in order to attain high performance-ization further, it is desirable to satisfy the following conditional expression (3).

$0.12<|fa|/(fw-ft)1/2<0.6$ (3)
The focal distance ft of the whole lens system [in / here / the focal distance fw:wide angle edge of fa:lens group Ga]: The focal distance of the whole lens system in a tele edge [0025] Conditional expression (3) is the conditional expression for aiming at balance of lessening the configuration lens number of sheets of having specified the focal distance of the lens group Ga and making still smaller focusing movement magnitude of the lens group Ga, and the lens group Ga. Since the focal distance of the lens group Ga becomes large negative when it exceeds the upper limit of conditional expression (3), the focusing movement magnitude of the lens group Ga will become large.
[0026] On the contrary, since the focal distance of the lens group Ga becomes small negative when less than the lower limit of conditional expression (3), focusing movement magnitude of the lens group Ga can be made small. However, since the axial outdoor daylight bunch which passes the lens group Ga approaches an optical axis, it will be difficult to amend shaft top aberration and the aberration outside a shaft independently by small lens number of sheets. Consequently, the workload at the time of focusing cannot be made small.
[0027] In this invention, raise in variable power and high performance-ization can be most attained further by arranging the 1st lens group G1 of a lens system which has positive refractive power in a body side, adjoining the image side of the 1st lens group G1, and arranging the two lens groups concerned which have negative refractive power. In addition, in this invention, it is also possible by constituting so that operating scale-factor betab of the lens group Ga in a wide angle edge may satisfy conditional expression (1) and the same following conditional expression (4) to cover the whole variable power range and to make small focusing movement magnitude of the lens group Ga.
(beta b-beta b-1) -2<0.8 (4)
[0028] Moreover, in this invention, it is desirable to satisfy the following conditional expression (5).
$0.3<fL1/fL2<5.0$ (5)
here -- fL1: -- the inside of the two negative lens groups concerned -- focal distance fL2: of the lens group by the side of a body -- the inside of the two negative lens groups concerned -- the focal distance [0029] of the lens group by the side of an image Conditional expression (5) is the conditional expression for aiming at balance of the focal distance of the two negative lens groups concerned which adjoined in the zoom lens and have been arranged. If it deviates from the range specified by the upper limit and lower limit of conditional expression (5), it will become impossible to suppress to coincidence fluctuation of many aberration generated at the time of variable power, and fluctuation of many aberration generated at the time of focusing good.
[0030] Moreover, in order to suppress still better fluctuation of the chromatic aberration generated at the time of focusing, it is desirable to amend chromatic aberration sufficiently good in the lens group Ga. For this reason, as for the greatest value nuGa, it is desirable to satisfy the following conditional expression (6) among the Abbe numbers of all the negative lens components contained in the lens group Ga.
nuGa> 35 (6)
Moreover, in order to suppress generating of comatic aberration and to obtain the still better image formation engine performance, as for the greatest value nGa, it is desirable to satisfy the following conditional expression (7) among the refractive indexes of all the negative lens components contained in the lens group Ga.
nGa>1.60 (7)
[0031] Moreover, in this invention, it becomes easy to attain high-performance-izing, raise in variable power, or diameter-ization of macrostomia further by introducing at least one aspheric surface into one which constitutes a zoom lens of lens groups. Furthermore, although it is possible to make it move in the direction which intersects perpendicularly with an optical axis mostly, and to carry out the image shift of one or more lens groups, it is also possible to obtain the good image formation engine performance also at the time of an image shift.
[0032]
[Example] Hereafter, each example of this invention is explained based on an accompanying

drawing.
[Example 1] Drawing 2 is the refractive-power plot plan of the zoom lens concerning the 1st example of this invention. The zoom lens of drawing 2 sequentially from a body side The 1st lens group G1 of positive refractive power, The 2nd lens group G2 of negative refractive power, 3rd lens group G3 of negative refractive power, and the 4th lens group G4 of positive refractive power, Have the 5th lens group G5 of negative refractive power, and the variable power from a wide angle edge (W) to a tele edge (T) is faced. The gap of the 1st lens group G1 and the 2nd lens group G2 increases, and the gap of the 2nd lens group G2 and 3rd lens group G3 increases. The gap of 3rd lens group G3 and the 4th lens group G4 decreases, and each lens group moves the gap of the 4th lens group G4 and the 5th lens group G5 to a body side so that it may decrease. In addition, focusing to a short-distance body is performed by moving 3rd lens group G3 in accordance with an optical axis.
[0033] Drawing 3 is drawing showing the lens configuration of the zoom lens concerning the 1st example of this invention. The 1st lens group G1 which the zoom lens of drawing 3 becomes from the negative meniscus lens L11 which turned the convex to the body side, and a biconvex lens L12 sequentially from a body side, The 2nd lens group G2 which consists of a cementation negative lens L21 of a biconcave lens and a biconvex lens, 3rd lens group G3 which consists of a negative meniscus lens L31 which turned the concave surface to the body side, The 4th lens group G4 which consists of a biconvex lens L41 and a cementation positive lens L42 of a biconvex lens and the negative meniscus lens which turned the concave surface to the body side, It consists of 5th lens groups G5 which consist of the positive meniscus lens L51 which turned the concave surface to the body side, a negative meniscus lens L52 which turned the concave surface to the body side, and a negative meniscus lens L53 which turned the concave surface to the body side.
[0034] In addition, aperture-diaphragm S is arranged between 3rd lens group G3 and the 4th lens group G4, and moves in one with the 4th lens group G4 on the occasion of the variable power from a wide angle edge to a tele edge. Drawing 3 shows the physical relationship of each lens group in a wide angle edge, and moves an optical-axis top to drawing 2 in accordance with the zoom orbit shown by the arrow head at the time of the variable power to a tele edge.
[0035] The value of the item of the example 1 of this invention is hung up over the following table (1). a table (1) -- setting -- f -- a focal distance -- in FNO, 2omega of field angles is expressed and Bf expresses a back focus for the f number. Furthermore, a refractive index and the Abbe number show the value [as opposed to d line (lambda= 587.6nm) for the sequence of the lens side from the body side with which the field number met in the direction in which light advances], respectively.
[0036]
[A table 1]
f=38.8-110.5 FNO=4.1 - 8.02 omega= 57.8 degrees - 21.4-degree side number Radius of curvature A spacing Refractive index Abbe number 1 38.7385 1.633 1.80518 25.35 2 21.3035 0.628 3 21.0319 3.893 1.62280 57.03 4 - 341.0792 (d4 = adjustable) 5 - 51.9442 1.256 1.77279 49.45 6 17.0448 2.888 1.75520 27.61 7-133.8779 (d7 = adjustable) 8-19.9515 1.256 1.77279 49.45 9 -151.1844 (d9 = adjustable) 10 infinity 1.884 (aperture-diaphragm S)
11 89.4983 2.009 1.62041 60.14 12 - 28.8833 0.126 13 44.5675 3.391 1.51860 69.98 14 - 11.5129 1.507 1.80518 25.35 15 - 20.3434 (d15= adjustable) 16 - 54.3667 3.140 1.80518 25.35 17 - 21.7045 0.628 18 - 48.6549 1.507 1.84042 43.35 19 -141.6808 4.14420 -14.7784 1.507 1.7727949.45 21 -280.6453 (Bf) (variable spacing in variable power)
f 38.7626 110.4625d4 1.9829 15.1690d7 3.7630 6.2747d9 4.1545 1.6429d15 14.9653 1.7792 Bf 10.0151 51.8560 (photography scale-factor-1/40 time o'clock focusing movement magnitude of 3rd lens group G3)
Focal distance f 38.7626 110.4625 movement magnitude delta -1.0496 -1.1477 (however, the sign of the focusing movement magnitude delta makes the travelling direction of light positive)
(Value corresponding to conditions)
fa=-29.8672 fL1=-99.2862 fL2=-29.8672 betaa=-0.4612 betab=-0.2080 (1) and (beta a-beta a-1) -2 = 0.343 (2) betaa/betab = 2.217(3) |fa|/(fw-ft)1/2 = 0.208 (4) and (beta b-beta b-1) -2 =

0.047 (5) fL1/fL2 = 3.324(6) nuGa =49.45(7) nGa = 1.77279 [0037] Drawing 4 thru/or drawing 7 are many aberration drawings to d line (lambda= 587.6nm) of an example 1. Drawing 4 is many aberration drawings in the infinite distance focus condition in a wide angle edge (the shortest focal distance condition), and drawing 5 is many aberration drawings in the infinite distance focus condition in a tele edge (the longest focal distance condition). On the other hand, drawing 6 is a photography scale factor in a wide angle edge. – It is many aberration drawings in 1/40 of focus conditions, and drawing 7 is a photography scale factor in a tele edge. – They are many aberration drawings in 1/40 of focus conditions.
[0038] In each aberration drawing, FNO shows the body high [as opposed to / in H / f number / each image quantity for a field angle / as opposed to / in A / NA / numerical aperture / Y / each image quantity for image quantity], respectively. Moreover, in aberration drawing showing astigmatism, a continuous line shows the sagittal image surface, and the dashed line shows the meridional image surface. Furthermore, in aberration drawing showing spherical aberration, the dashed line shows sign condition (sine condition). In this example, it turns out that many aberration is amended good ranging from the infinite distance focus condition to a short-distance focus condition in each focal distance condition so that clearly from each aberration drawing.
[0039] [Example 2] Drawing 8 is the refractive-power plot plan of the zoom lens concerning the 2nd example of this invention. The zoom lens of drawing 8 sequentially from a body side The 1st lens group G1 of positive refractive power, Have the 2nd lens group G2 of negative refractive power, and 3rd lens group G3 of positive refractive power, and the variable power from a wide angle edge (W) to a tele edge (T) is faced. The gap of the 1st lens group G1 and the 2nd lens group G2 increases, and each lens group moves the gap of the 2nd lens group G2 and 3rd lens group G3 to a body side so that it may decrease. In addition, the 2nd lens group G2 consists of lens group G2a which has the negative refractive power by the side of a body, and lens group G2b which has the negative refractive power by the side of an image, and performs focusing to a short-distance body by moving lens group G2a by the side of a body in accordance with an optical axis.
[0040] Drawing 9 is drawing showing the lens configuration of the zoom lens concerning the 2nd example of this invention. The 1st lens group G1 which consists of a cementation positive lens L12 of the negative meniscus lens and biconvex lens with which the zoom lens of drawing 9 turned the biconvex lens L11, and turned the convex to the body side sequentially from the body side, Lens group G2a which consists of a cementation negative lens L21 of a biconcave lens and the positive meniscus lens which turned the convex to the body side, and the 2nd lens group G2 which consists of lens group G2b which consists of a negative meniscus lens L22 which turned the concave surface to the body side, To a biconvex lens L31, biconvex lens, and body side, a concave surface It consists of 3rd lens group G3 which consists of the cementation positive lens L32 with the turned negative meniscus lens, the positive meniscus lens L33 which turned the convex to the body side, a negative meniscus lens L34 which turned the concave surface to the body side, and a positive meniscus lens L35 which turned the concave surface to the body side.
[0041] In addition, aperture-diaphragm S is arranged between the positive meniscus lens L33 in 3rd lens group G3, and a negative meniscus lens L34, and moves in one with 3rd lens group G3 on the occasion of the variable power from a wide angle edge to a tele edge. Moreover, fixed drawing S' is arranged like illustration at the image side of aperture-diaphragm S. Drawing 9 shows the physical relationship of each lens group in a wide angle edge, and moves an optical-axis top to drawing 8 in accordance with the zoom orbit shown by the arrow head at the time of the variable power to a tele edge.
[0042] The value of the item of the example 2 of this invention is hung up over the following table (2). a table (2) -- setting -- f -- a focal distance -- in FNO, 2omega of field angles is expressed and Bf expresses a back focus for the f number. Furthermore, a refractive index and the Abbe number show the value [as opposed to d line (lambda= 587.6nm) for the sequence of the lens side from the body side with which the field number met in the direction in which light advances], respectively.
[0043]

[A table 2]
f=85.5-191.0 FNO=4.7 - 5.62 omega= 29.0 degrees - 12.7-degree side number Radius of curvature A spacing Refractive index Abbe number 1 132.8387 4.000 1.51680 64.12 2 3064. 5789 0.115 3 88.6525 2.000 1.80458 25.49 4 50.6836 5.000 1.51680 64.12 5 - 399.3308 (d5 = adjustable) 6 - 140.88891.200 1.69680 55.60 7 23.1440 3.500 1.84666 23.82 850.7877 13.000 9 - 45.6950 1.000 1.65160 58.54 10 - 996.6611 (d10= adjustable) 11 106.2788 5.175 1.50137 56.46 12-48.1738 0.230 13 84.4967 6.095 1.51860 70.08 14 - 36.8350 1.610 1.75520 27.64 15 -642.3547 0.920 16 32.6932 4.140 1.7130053.97 17 52.1070 3.220 18 infinity 22.310 (aperture-diaphragm S) 19 infinity 20.700 (fixed drawing S')
20 -18.8960 2.415 1.76684 46.76 21 -53.3018 0.230 22 -227.2534 3.220 1.72825 28.34 23 - 37.5483 (Bf) (Variable Spacing in Variable Power)
f 85.5000 191.0000d5 1.4053 33.1577d10 21.6093 5.5585 Bf 45.9663 62.0168 (focusing movement magnitude of lens group Gphotography scale-factor-1/30 time o'clock2a)
Focal distance f 85.5000 191.0000 movement magnitude delta +8.4418 +2.5356 (however, the sign of the focusing movement magnitude delta makes the travelling direction of light positive)
(Value corresponding to conditions)
fa=-66.1034 fL1=-73.5277 fL2=-66.1034 betaa=-5.7383 betab=-1.5276 (1) and (beta a-beta a-1) -2 = 0.032 (2) betaa/betab = 3.756(3) |fa|/(fw-ft)1/2 = 0.268 (4) and (beta b-beta b-1) -2 = 1.312 (5) fL1/fL2 = 1.112(6) nuGa =55.60(7) nGa = 1.69680 [0044] Drawing 10 thru/or drawing 13 are many aberration drawings to d line (lambda= 587.6nm) of an example 2. Drawing 10 is many aberration drawings in the infinite distance focus condition in a wide angle edge, and drawing 11 is many aberration drawings in the infinite distance focus condition in a tele edge. On the other hand, drawing 12 is a photography scale factor in a wide angle edge. - It is many aberration drawings in 1/30 of focus conditions, and drawing 13 is a photography scale factor in a tele edge. - They are many aberration drawings in 1/30 of focus conditions.
[0045] In each aberration drawing, FNO shows the body high [as opposed to / in H / f number / each image quantity for a field angle / as opposed to / in A / NA / numerical aperture / Y / each image quantity for image quantity], respectively. Moreover, in aberration drawing showing astigmatism, a continuous line shows the sagittal image surface, and the dashed line shows the meridional image surface. Furthermore, in aberration drawing showing spherical aberration, the dashed line shows sign condition (sine condition). In this example, it turns out that many aberration is amended good ranging from the infinite distance focus condition to a short-distance focus condition in each focal distance condition so that clearly from each aberration drawing.
[0046] [Example 3] Drawing 14 is the refractive-power plot plan of the zoom lens concerning the 3rd example of this invention. The zoom lens of drawing 14 sequentially from a body side The 1st lens group G1 of positive refractive power, Have the 2nd lens group G2 of negative refractive power, 3rd lens group G3 of positive refractive power, and the 4th lens group G4 of positive refractive power, and the variable power from a wide angle edge (W) to a tele edge (T) is faced. The gap of the 1st lens group G1 and the 2nd lens group G2 increases, the gap of the 2nd lens group G2 and 3rd lens group G3 decreases, and the 2nd lens group G2 and 3rd lens group G3 move the gap of 2nd lens group G3 and the 3rd lens group G4 so that it may change. In addition, the 2nd lens group G2 consists of lens group G2a which has the negative refractive power by the side of a body, and lens group G2b which has the negative refractive power by the side of an image, and performs focusing to a short-distance body by moving lens group G2a by the side of a body in accordance with an optical axis.
[0047] Drawing 15 is drawing showing the lens configuration of the zoom lens concerning the 3rd example of this invention. The 1st lens group G1 which the zoom lens of drawing 15 becomes from the cemented lens L11 of the negative meniscus lens and biconvex lens which turned the convex to the body side, and the positive meniscus lens L12 which turned the convex to the body side sequentially from a body side, Lens group G2a which consists of a cemented lens L22 of the biconcave lens configuration which has the plane of composition which turned the concave surface to the negative meniscus lens [which turned the convex to the body side] L21, and body side, And the 2nd lens group G2 which consists of lens group G2b which consists

of the cemented lens L23 and biconcave lens L24 of a biconcave lens configuration which have the plane of composition which turned the convex to the body side, 3rd lens group G3 which consists of a biconvex lens L31 and a cementation positive lens L32 of a biconvex lens and the negative meniscus lens which turned the concave surface to the body side, To a body side, a convex It consists of 4th lens groups G4 which consist of the turned positive meniscus lens L41, the positive meniscus lens L42 which turned the convex to the body side, the negative meniscus lens L43 which turned the convex to the body side, a biconvex lens L44, and a negative meniscus lens L45 which turned the concave surface to the body side.
[0048] In addition, aperture-diaphragm S is arranged between 3rd lens group G3 and the 4th lens group G4, and moves in one with the 4th lens group G4 on the occasion of the variable power from a wide angle edge to a tele edge. Moreover, in the 4th lens group G4, fixed drawing S' is arranged like illustration. Drawing 15 shows the physical relationship of each lens group in a wide angle edge, and the 2nd lens group G2 and 3rd lens group G3 move an optical-axis top to drawing 14 in accordance with the zoom orbit shown by the arrow head at the time of the variable power to a tele edge. However, the 1st lens group G1 and the 4th lens group G4 are immobilization in accordance with the optical axis in variable power.
[0049] The value of the item of the example 3 of this invention is hung up over the following table (3). a table (3) -- setting -- f -- a focal distance -- in FNO, 2omega of field angles is expressed and Bf expresses a back focus for the f number. Furthermore, a refractive index and the Abbe number show the value [as opposed to d line (lambda= 587.6nm) for the sequence of the lens side from the body side with which the field number met in the direction in which light advances], respectively.
[0050]
[A table 3]
f=81.5-196.0 FNO=2.8 - 2.8 2 omega= 30.7-18.1-degree side number Radius of curvature Spacing Refractive index Abbe number 1 105.5399 2.800 1.80458 25.50 2 73.4058 11.400 1.49782 82.52 3 - 570.0625 0.100 4 118.0775 5.700 1.49782 82.52 5 1042. 0722 (d5 = adjustable) 6 322.9129 2.100 1.74810 52.30 7122.57663.8508 -118.7333 3.500 1.8045825.50 9 - 61.4330 1.600 1.56384 60.6910 262.6263 19.63111 - 119.9235 1.500 1.58130 61.09 1242.1223 4.500 1.80458 25.50 13 118.0410 2.400 14 - 181.3955 1.800 1.7966845.3715 139.1660 (d15= adjustable) 16 302.2780 3.300 1.58270 46.42 17 - 143.1744 0.100 18 143.7170 6.900 1.51860 69.98 19 -49.9410 1.600 1.80458 25.50 20 -113.3388 (d20= adjustable) 21 infinity 1.500 (aperture-diaphragm S) 22 65.9782 3.100 1.49782 82.52 23 163.6723 0.100 24 37.7279 5.200 1.49782 82.52 25 67.7955 11.682 26 79.1100 2.400 1.80458 25.50 27 46.4525 4.942 28 infinity 15.500 (fixed drawing S') 29 65.3317 4.800 1.79613 40.90 30 -244.7240 10.475 31 -38.3284 2.500 1.77279 49.45 32 - 122.1555 (Bf) (Variable Spacing in Variable Power)
f 81.5039 196.0000d5 1.9240 38.1174d15 27.2250 2.3519d20 15.6184 4.2981Bf 50.6056 50.6056 (focusing movement magnitude of lens group Gphotography scale-factor-1/30 time o'clock2a) Focal distance f 81.5039 196.0000 movement magnitude delta +6.4919 +4.1781 (however, the sign of the focusing movement magnitude delta makes the travelling direction of light positive) (Focusing movement magnitude of lens group G2a at photography distance 1.5 m:00)
Focal distance f 81.5039 196.0000 movement magnitude delta 13.8134 15.6683 (however, the sign of the focusing movement magnitude delta makes the travelling direction of light positive) (Value corresponding to conditions)
fa=-113.5000fL1=-113.5000fL2=-58.8237betaa= 2.9729betab= 57.1837 (1) and (beta a-beta a-1) -2 = 0.144 (2) betaa/betab = 0.052(3) |fa|/(fw-ft)1/2 = 0.806 (4) and (beta b-beta b-1) -2 = 0.0003 (5) fL1/fL2 = 1.929(6) nuGa =60.69(7) nGa = 1.74810 [0051] Drawing 16 thru/or drawing 21 are many aberration drawings to d line (lambda= 587.6nm) of an example 3. Drawing 16 is many aberration drawings in the infinite distance focus condition in a wide angle edge, and drawing 17 is many aberration drawings in the infinite distance focus condition in a tele edge. Moreover, drawing 18 is a photography scale factor in a wide angle edge. - It is many aberration drawings in 1/30 of focus conditions, and drawing 19 is a photography scale factor in a tele edge. - They are many aberration drawings in 1/30 of focus conditions. Furthermore, drawing 20 is many aberration drawings in the photography distance of 1.5m in a wide angle edge, and drawing

21 is many aberration drawings in the photography distance of 1.5m in a tele edge.
[0052] In each aberration drawing, FNO shows the body high [as opposed to / in H / f number / each image quantity for a field angle / as opposed to / in A / NA / numerical aperture / Y / each image quantity for image quantity], respectively. Moreover, in aberration drawing showing astigmatism, a continuous line shows the sagittal image surface, and the dashed line shows the meridional image surface. Furthermore, in aberration drawing showing spherical aberration, the dashed line shows sign condition (sine condition). In this example, it turns out that many aberration is amended good ranging from the infinite distance focus condition to a short-distance focus condition in each focal distance condition so that clearly from each aberration drawing.
[0053]
[Effect] As explained above, according to this invention, the zoom lens in which focusing is possible at small movement magnitude, and the short-distance focus which was excellent in the image formation engine performance from the long distance body to the short-distance body is possible is realizable.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to a zoom lens applicable also to the bright zoom lens especially whose aperture ratio is about 2.8 about the zoom lens in which a short-distance focus is possible.

[Translation done.]

PRIOR ART

[Description of the Prior Art] As orientation in the latest camera, two points, the cameras in which ** automatic focus is possible are increasing in number [that a zoom lens is becoming in use / ** taking lens / and], are mentioned.
[0003] The various zoom types which attained raise in variable power and high performance-ization have been proposed as a zoom lens becomes in use. Moreover, the zoom type which attained high variable power-ization by advance of lens-barrel technology in recent years etc. using the so-called multi-group zoom lens constituted by the three or more-group moving lens group is proposed variously. Moreover, with the camera in which an automatic focus is possible, improvement in the speed of focusing (focus) actuation is progressing. And various methods are proposed also about the focusing method in a multi-group zoom lens with improvement in the speed of focusing actuation.

[Translation done.]

EFFECT OF THE INVENTION

[Effect] As explained above, according to this invention, the zoom lens in which focusing is possible at small movement magnitude, and the short-distance focus which was excellent in the image formation engine performance from the long distance body to the short-distance body is possible is realizable.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Generally, in order to attain improvement in the speed of focusing actuation, being required of a focusing glass group (lens group which moves in accordance with an optical axis at the time of focusing) is making small the workload at the time of focusing (= weight x movement magnitude). However, in the conventional zoom lens, there was un-arranging [that the workload at the time of focusing was not sufficiently small].
[0005] This invention is made in view of the above-mentioned technical problem, and aims at offering the zoom lens in which focusing is possible at small movement magnitude, and the short-distance focus which was excellent in the image formation engine performance is possible.

[Translation done.]

MEANS

[Means for Solving the Problem] In order to solve said technical problem, it sets to this invention. In a zoom lens which was equipped with two lens groups which adjoin mutually, are arranged [both] and have negative refractive power at least and in which a short-distance focus is possible On the occasion of variable power, move the movable lens group Ga in accordance with an optical axis between said two lens groups, and a focus to a short-distance body is performed. When an operating scale factor in a tele edge in an infinite distance focus condition of said lens group Ga is set to betaa and an operating scale factor in a wide angle edge in an infinite distance focus condition of said lens group Ga is set to betab, A zoom lens which is characterized by satisfying conditions of (beta a-beta a-1)-2<0.8beta a/beta b> 0 and in which a short-distance focus is possible is offered.
[0007] When according to the desirable mode of this invention a focal distance of said lens group Ga is set to fa, a focal distance of the whole lens system in a wide angle edge is set to fw and a focal distance of the whole lens system in a tele edge is set to ft, conditions of 0.12<|fa|/(fw-ft) 1/2 <0.6 are satisfied.

[Translation done.]

OPERATION

[Function] First, the generalities about the so-called multi-group zoom lens constituted by the three or more-group moving lens group are described. In a multi-group zoom lens, since whenever [option] increases into the zooming orbit of each lens group which faces the variable power from a wide angle edge to a tele edge, the flexibility on aberration amendment increases. Moreover, since the lens group which bears variable power increases, it becomes easy to carry out the equation of the variable power burden of each lens group. In this way, it becomes possible to attain high performance-ization, attaining high variable power-ization. In addition, although there were also problems, such as complication of the lens-barrel structure accompanying the increment for moving part, it is conquered to some extent by advance of lens-barrel technology in recent years.
[0009] Next, focusing in a multi-group zoom lens is described. Generally, being required of a focusing glass group are that there is little focusing movement magnitude and that the weight of a focusing glass group is small as mentioned above. This can be tied to the miniaturization of a lens system, so that there is little focusing movement magnitude, and it is because simplification of the drive of a lens can be attained, so that the weight of a focusing glass group is small.
[0010] Before, when performing the focus to a short-distance body in a multi-group zoom lens, various proposals are made about the following three methods.
(A) 1 group delivery method (B) IF (inner focus) method (C) RF (rear focus) method [0011] Before, with 4 group zoom lens right positive in positive/negative, 1 group delivery method of (A) is used for order for example, from a body side. However, since the 1st lens group separates from the image surface most and is arranged, its diameter of a lens is large. Consequently, the 1st lens group is seldom suitable for the focusing glass group. Moreover, the example which is made to move the 2nd lens group of immobilization among variable power to JP,5-224123,A by these people, and performs focusing of the inner focus method of (B) to it in 5 group zoom lens of positive/negative negative positive/negative sequentially from a body side is indicated. However, since the 2nd lens group is immobilization among variable power, the 2nd lens group cannot be made to contribute to a variable power operation positively, and it cannot be said that it is enough in respect of high-performance-izing.
[0012] Furthermore, the example which is made to move the 4th lens group of 4 group zoom lens of positive/negative positive/negative to JP,61-50112,A sequentially from a body side, and performs focusing of the rear focus method of (C) to it is indicated. However, since the diameter of a lens is large, the 4th lens group is seldom suitable for the focusing glass group.
[0013] Here, migration of the focusing glass group at the time of moving one lens group and performing focusing is described. If the focusing glass group Gf is moved so that the location of the object point by the 1st lens group G1 thru/or the focusing glass group Gf to the lens group Gh arranged at the image side of the focusing glass group Gf may become fixed when the location of a photographic subject moves at a short distance from a long distance, a short-distance focus can be performed. Under the present circumstances, the conditions which make small movement magnitude delta of the focusing glass group Gf are explained using a thin lens system.
[0014] First, in order to make regularity the location of the object point to the lens group Gh

when the location of the object point to the focusing glass group Gf moves only delta as shown in drawing 1 , only delta shall move the lens group Gf. In this case, if the image formation scale factor of the lens group Gf is set to beta, the movement magnitude delta of the focusing glass group Gf will be given with the following formula (a).
delta= [beta2/(beta2-1)] -delta (a)
[0015] (a) The value of k is beta 2 in a formula when k=beta 2/(beta2-1). It comes to express with the following formula (b) and (c) depending on a value.
k>=1 (beta2 > 1) (b)
k< 0 (beta2 <1) (c)
[0016] Therefore, in order to make small magnitude of the movement magnitude delta of the lens group Gf, to be (c), k is brought as much as possible close to 0, namely, it is required [k is brought as much as possible close 1, namely, / it is required to bring 1/beta close to 0, and] in (b), to bring beta close to 0.
[0017] In the zoom lens which has at least two lens groups which adjoin mutually, are arranged [both] and have negative refractive power in this invention based on the above consideration While bringing the inverse number of the operating scale factor of the lens group arranged between these two lens groups at the body side close to 0 By bringing the operating scale factor of the lens group arranged at the image side close to 0, even if it moves which lens group between two above-mentioned lens groups at the time of focusing, the focusing movement magnitude can be made small. In this invention, in order that drawing may tie equalization of the burden of the variable power of each lens group to high variable power-ization, the movable lens group Ga is moved between two lens groups at the time of focusing at the time of variable power.
[0018] This invention is made based on the above technological backgrounds, and in a zoom lens with which both two lens groups arranged adjacently have negative refractive power and in which a short-distance focus is possible, it aims at solution of the above-mentioned technical problem by fulfilling predetermined conditions while it moves the movable lens group Ga on the occasion of variable power between two lens groups and performs focusing to a short-distance body.
[0019] Hereafter, the monograph affair type of this invention is explained. It is satisfied with the zoom lens of this invention of the following conditional expression (1) and (2).
(beta a-beta a-1) -2<0.8 (1)
beta a/beta b> 0 (2)
Scale-factor [operating] betab [in / here / the tele edge in the infinite distance focus condition of the betaa:lens group Ga]: The operating scale factor in the wide angle edge in the infinite distance focus condition of the lens group Ga [0020] Conditional expression (1) is conditional expression which specifies the operating scale factor in the tele edge of the focusing glass group Ga. As mentioned above, the focusing movement magnitude (movement magnitude which faces focusing) delta of the lens group Ga is expressed with a formula (a), and can make small focusing movement magnitude delta of the lens group Ga by making magnitude of k small.
[0021] In addition, conditional expression (1) is 2 (k/beta) by deforming. It is expressed. That is, in conditional expression (1), the feature of this invention which makes small focusing movement magnitude delta of the lens group Ga is emphasized by making magnitude of k small by carrying out the square of the ratio of k and beta. When it exceeds the upper limit of conditional expression (1), the focusing movement magnitude of the lens group Ga will become large. In addition, in this invention, in order to stop the focusing movement magnitude of the lens group Ga still smaller, it is desirable to set the upper limit of conditional expression (1) to 0.5.
[0022] As mentioned above, in the case of beta2 >1, if 1/beta is brought close to 0, focusing can be performed with small movement magnitude. However, if the location used as 1/beta= 0 exists in the variable power from a wide angle edge to a tele edge, since k will decrease from a wide angle edge up to the location of 1/beta= 0 and k will increase from the location of 1/beta= 0 to a tele edge, control of the lens group Ga will become difficult. Moreover, in the case of beta2 <1, if beta is brought close to 0, focusing can be performed with small movement magnitude. However, if the location used as beta= 0 exists in the variable power from a wide angle edge to a tele edge, since k will decrease from a wide angle edge up to the location of beta= 0 and k will increase

from the location of beta= 0 to a tele edge, control of the lens group Ga will become difficult.
[0023] Conditional expression (2) has specified the suitable range about the ratio of operating scale-factor betaa of the lens group Ga in a tele edge, and operating scale-factor betab of the lens group Ga in a wide angle edge. When less than the lower limit of conditional expression (2), 1/beta or beta will include the location set to 0 in the variable power from a wide angle edge to a tele edge. For this reason, as mentioned above, control of the lens group Ga will become difficult. Especially, the amount of deliveries to the same photography distance decreases once, and increases from the middle as it carries out variable power to a tele edge from a wide angle edge. For this reason, it will become difficult to carry out position control of the focusing glass group.
[0024] Moreover, in this invention, in order to attain high performance-ization further, it is desirable to satisfy the following conditional expression (3).
$0.12<|fa|/(fw-ft)1/2 <0.6$ (3)
The focal distance ft of the whole lens system [in / here / the focal distance fw:wide angle edge of fa:lens group Ga]: The focal distance of the whole lens system in a tele edge [0025] Conditional expression (3) is the conditional expression for aiming at balance of lessening the configuration lens number of sheets of having specified the focal distance of the lens group Ga and making still smaller focusing movement magnitude of the lens group Ga, and the lens group Ga. Since the focal distance of the lens group Ga becomes large negative when it exceeds the upper limit of conditional expression (3), the focusing movement magnitude of the lens group Ga will become large.
[0026] On the contrary, since the focal distance of the lens group Ga becomes small negative when less than the lower limit of conditional expression (3), focusing movement magnitude of the lens group Ga can be made small. However, since the axial outdoor daylight bunch which passes the lens group Ga approaches an optical axis, it will be difficult to amend shaft top aberration and the aberration outside a shaft independently by small lens number of sheets. Consequently, the workload at the time of focusing cannot be made small.
[0027] In this invention, raise in variable power and high performance-ization can be most attained further by arranging the 1st lens group G1 of a lens system which has positive refractive power in a body side, adjoining the image side of the 1st lens group G1, and arranging the two lens groups concerned which have negative refractive power. In addition, in this invention, it is also possible by constituting so that operating scale-factor betab of the lens group Ga in a wide angle edge may satisfy conditional expression (1) and the same following conditional expression (4) to cover the whole variable power range and to make small focusing movement magnitude of the lens group Ga.
(beta b-beta b-1) $-2<0.8$ (4)
[0028] Moreover, in this invention, it is desirable to satisfy the following conditional expression (5).
$0.3<fL1/fL2<5.0$ (5)
here -- fL1: -- the inside of the two negative lens groups concerned -- focal distance fL2: of the lens group by the side of a body -- the inside of the two negative lens groups concerned -- the focal distance [0029] of the lens group by the side of an image Conditional expression (5) is the conditional expression for aiming at balance of the focal distance of the two negative lens groups concerned which adjoined in the zoom lens and have been arranged. If it deviates from the range specified by the upper limit and lower limit of conditional expression (5), it will become impossible to suppress to coincidence fluctuation of many aberration generated at the time of variable power, and fluctuation of many aberration generated at the time of focusing good.
[0030] Moreover, in order to suppress still better fluctuation of the chromatic aberration generated at the time of focusing, it is desirable to amend chromatic aberration sufficiently good in the lens group Ga. For this reason, as for the greatest value nuGa, it is desirable to satisfy the following conditional expression (6) among the Abbe numbers of all the negative lens components contained in the lens group Ga.
$nuGa> 35$ (6)
Moreover, in order to suppress generating of comatic aberration and to obtain the still better image formation engine performance, as for the greatest value nGa, it is desirable to satisfy the

following conditional expression (7) among the refractive indexes of all the negative lens components contained in the lens group Ga.

nGa>1.60 (7)

[0031] Moreover, in this invention, it becomes easy to attain high-performance-izing, raise in variable power, or diameter-ization of macrostomia further by introducing at least one aspheric surface into one which constitutes a zoom lens of lens groups. Furthermore, although it is possible to make it move in the direction which intersects perpendicularly with an optical axis mostly, and to carry out the image shift of one or more lens groups, it is also possible to obtain the good image formation engine performance also at the time of an image shift.

[Translation done.]

EXAMPLE

[Example] Hereafter, each example of this invention is explained based on an accompanying drawing.
[Example 1] Drawing 2 is the refractive-power plot plan of the zoom lens concerning the 1st example of this invention. The zoom lens of drawing 2 sequentially from a body side The 1st lens group G1 of positive refractive power, The 2nd lens group G2 of negative refractive power, 3rd lens group G3 of negative refractive power, and the 4th lens group G4 of positive refractive power, Have the 5th lens group G5 of negative refractive power, and the variable power from a wide angle edge (W) to a tele edge (T) is faced. The gap of the 1st lens group G1 and the 2nd lens group G2 increases, and the gap of the 2nd lens group G2 and 3rd lens group G3 increases. The gap of 3rd lens group G3 and the 4th lens group G4 decreases, and each lens group moves the gap of the 4th lens group G4 and the 5th lens group G5 to a body side so that it may decrease. In addition, focusing to a short-distance body is performed by moving 3rd lens group G3 in accordance with an optical axis.
[0033] Drawing 3 is drawing showing the lens configuration of the zoom lens concerning the 1st example of this invention. The 1st lens group G1 which the zoom lens of drawing 3 becomes from the negative meniscus lens L11 which turned the convex to the body side, and a biconvex lens L12 sequentially from a body side, The 2nd lens group G2 which consists of a cementation negative lens L21 of a biconcave lens and a biconvex lens, 3rd lens group G3 which consists of a negative meniscus lens L31 which turned the concave surface to the body side, The 4th lens group G4 which consists of a biconvex lens L41 and a cementation positive lens L42 of a biconvex lens and the negative meniscus lens which turned the concave surface to the body side, It consists of 5th lens groups G5 which consist of the positive meniscus lens L51 which turned the concave surface to the body side, a negative meniscus lens L52 which turned the concave surface to the body side, and a negative meniscus lens L53 which turned the concave surface to the body side.
[0034] In addition, aperture-diaphragm S is arranged between 3rd lens group G3 and the 4th lens group G4, and moves in one with the 4th lens group G4 on the occasion of the variable power from a wide angle edge to a tele edge. Drawing 3 shows the physical relationship of each lens group in a wide angle edge, and moves an optical-axis top to drawing 2 in accordance with the zoom orbit shown by the arrow head at the time of the variable power to a tele edge.
[0035] The value of the item of the example 1 of this invention is hung up over the following table (1). a table (1) -- setting -- f -- a focal distance -- in FNO, 2omega of field angles is expressed and Bf expresses a back focus for the f number. Furthermore, a refractive index and the Abbe number show the value [as opposed to d line (lambda= 587.6nm) for the sequence of the lens side from the body side with which the field number met in the direction in which light advances], respectively.
[0036]
[A table 1]
f=38.8-110.5 FNO=4.1 - 8.02 omega= 57.8 degrees - 21.4-degree side number Radius of curvature A spacing Refractive index Abbe number 1 38.7385 1.633 1.80518 25.35 2 21.3035 0.628 3 21.0319 3.893 1.62280 57.03 4 - 341.0792 (d4 = adjustable) 5 - 51.9442 1.256 1.77279

49.45 6 17.0448 2.888 1.75520 27.61 7−133.8779 (d7 = adjustable) 8−19.9515 1.256 1.77279 49.45
9 −151.1844 (d9 = adjustable) 10 infinity 1.884 (aperture−diaphragm S)
11 89.4983 2.009 1.62041 60.14 12 − 28.8833 0.126 13 44.5675 3.391 1.51860 69.98 14 − 11.5129
1.507 1.80518 25.35 15 − 20.3434 (d15= adjustable) 16 − 54.3667

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing explained by the thin lens system about the conditions at the time of performing the focus to a short-distance body.
[Drawing 2] It is the refractive-power plot plan of the zoom lens concerning the 1st example of this invention.
[Drawing 3] It is drawing showing the lens configuration of the zoom lens concerning the 1st example of this invention.
[Drawing 4] They are many aberration drawings in the infinite distance focus condition in the wide angle edge of an example 1.
[Drawing 5] They are many aberration drawings in the infinite distance focus condition in the tele edge of an example 1.
[Drawing 6] Photography scale factor in the wide angle edge of an example 1 - They are many aberration drawings in 1/40 of focus conditions.
[Drawing 7] Photography scale factor in the tele edge of an example 1 - They are many aberration drawings in 1/40 of focus conditions.
[Drawing 8] It is the refractive-power plot plan of the zoom lens concerning the 2nd example of this invention.
[Drawing 9] It is drawing showing the lens configuration of the zoom lens concerning the 2nd example of this invention.
[Drawing 10] They are many aberration drawings in the infinite distance focus condition in the wide angle edge of an example 2.
[Drawing 11] They are many aberration drawings in the infinite distance focus condition in the tele edge of an example 2.
[Drawing 12] Photography scale factor in the wide angle edge of an example 2 - They are many aberration drawings in 1/30 of focus conditions.
[Drawing 13] Photography scale factor in the tele edge of an example 2 - They are many aberration drawings in 1/30 of focus conditions.
[Drawing 14] It is the refractive-power plot plan of the zoom lens concerning the 3rd example of this invention.
[Drawing 15] It is drawing showing the lens configuration of the zoom lens concerning the 3rd example of this invention.
[Drawing 16] They are many aberration drawings in the infinite distance focus condition in the wide angle edge of an example 3.
[Drawing 17] They are many aberration drawings in the infinite distance focus condition in the tele edge of an example 3.
[Drawing 18] Photography scale factor in the wide angle edge of an example 3 - They are many aberration drawings in 1/30 of focus conditions.
[Drawing 19] Photography scale factor in the tele edge of an example 3 - They are many aberration drawings in 1/30 of focus conditions.
[Drawing 20] They are many aberration drawings in the photography distance of 1.5m in the wide angle edge of an example 3.

[Drawing 21] They are many aberration drawings in the photography distance of 1.5m in the tele edge of an example 3. .

[Description of Notations]

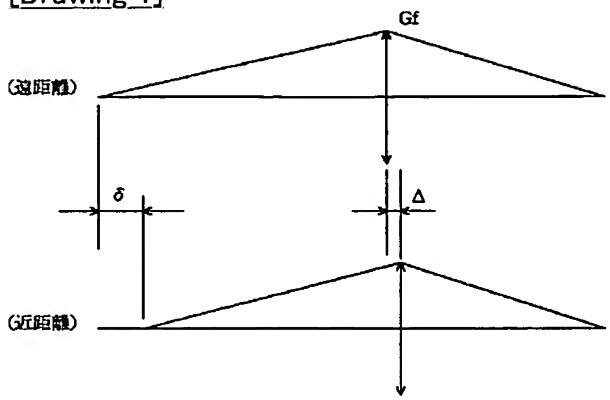
G1 The 1st lens group
G2 The 2nd lens group
G3 The 3rd lens group
G4 The 4th lens group
G5 The 5th lens group
S Aperture diaphragm

[Translation done.]

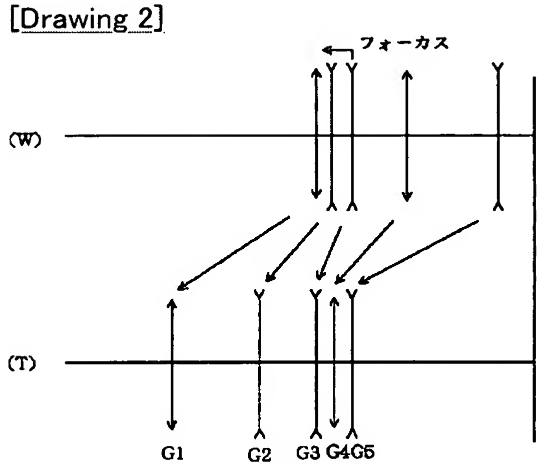
＊ NOTICES ＊

DRAWINGS

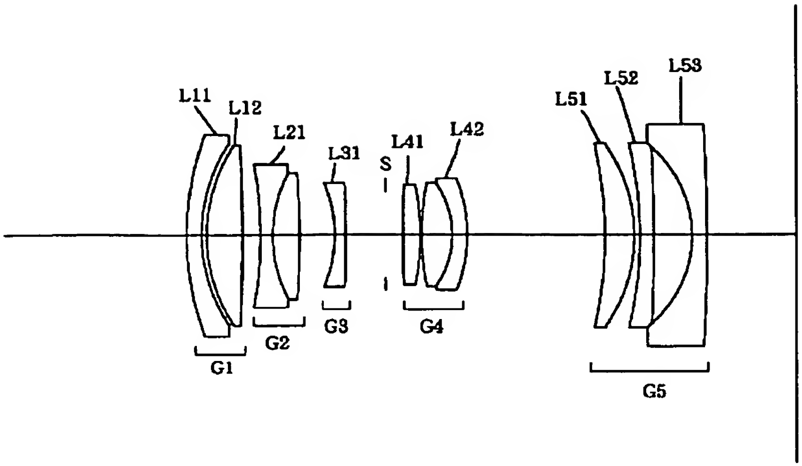
[Drawing 1]



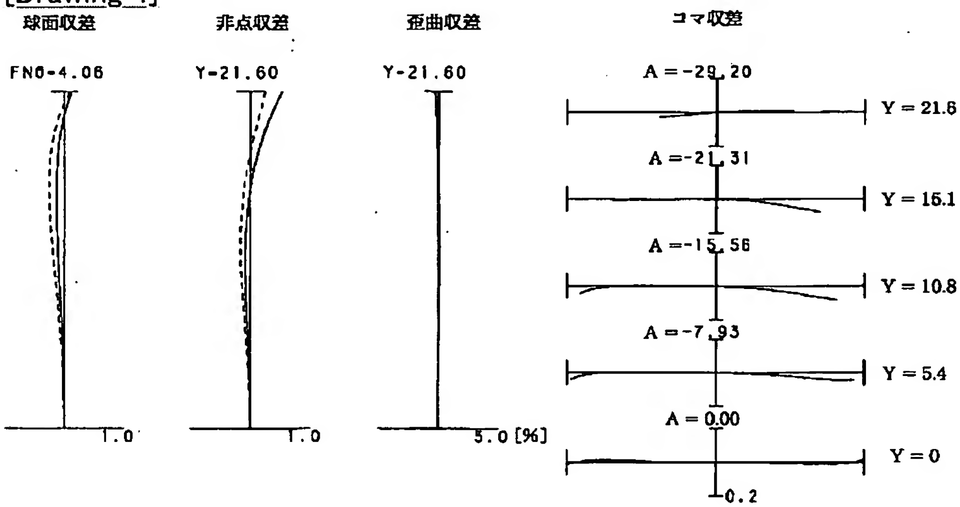
[Drawing 2]



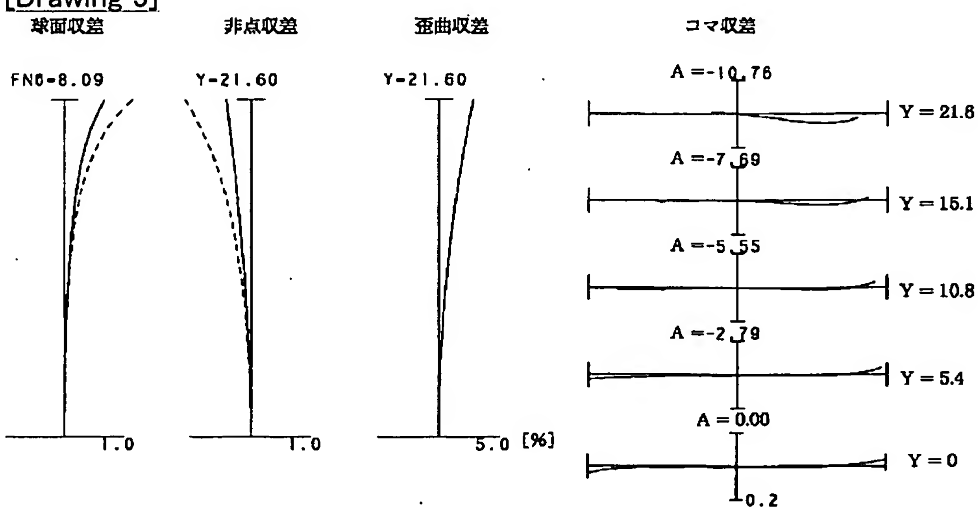
[Drawing 3]



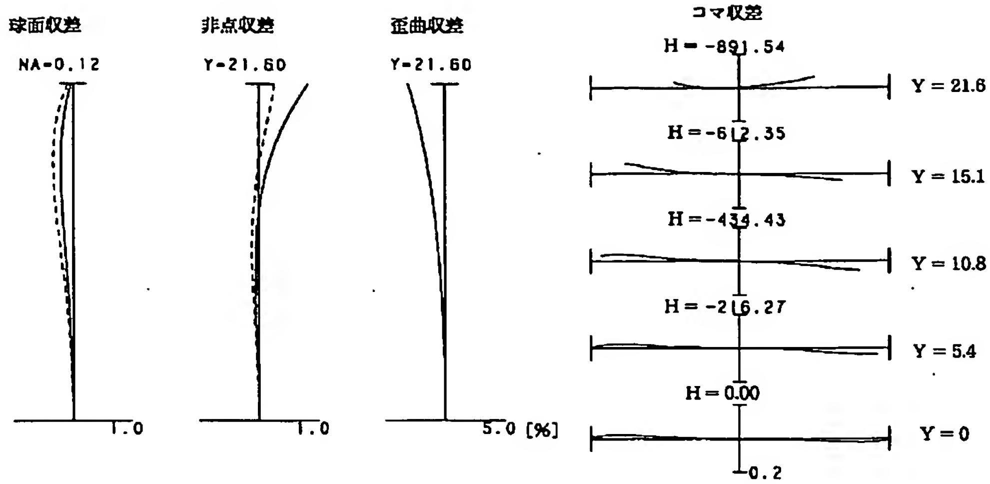
[Drawing 4]



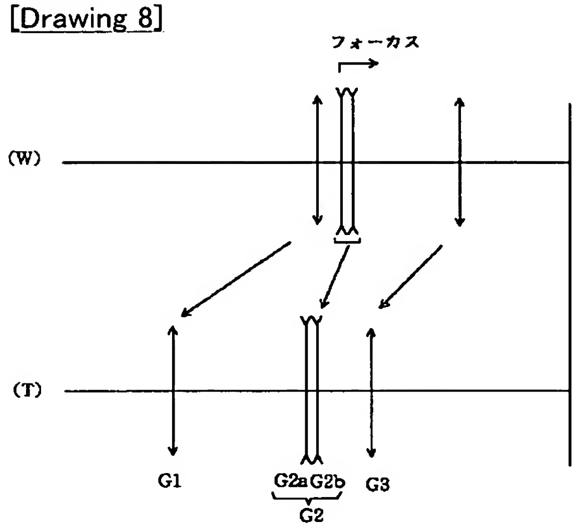
[Drawing 5]



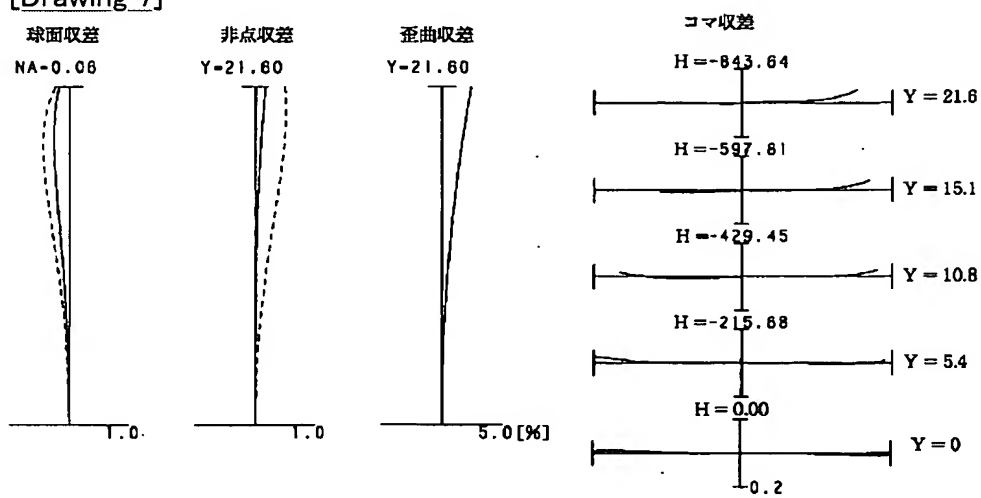
[Drawing 6]



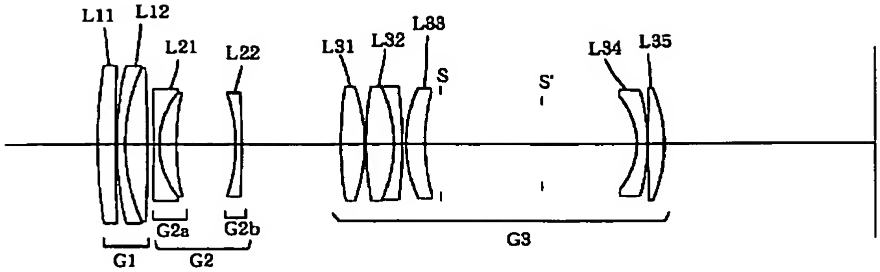
[Drawing 8]



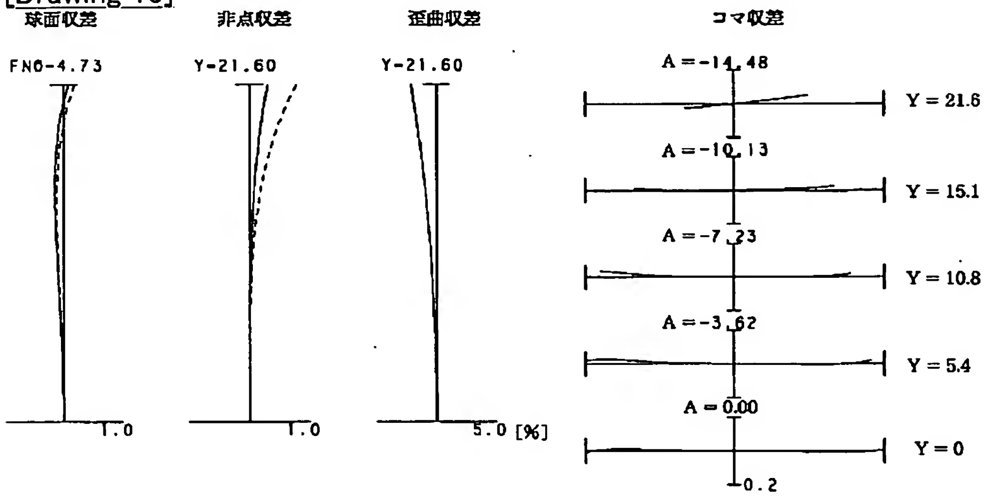
[Drawing 7]



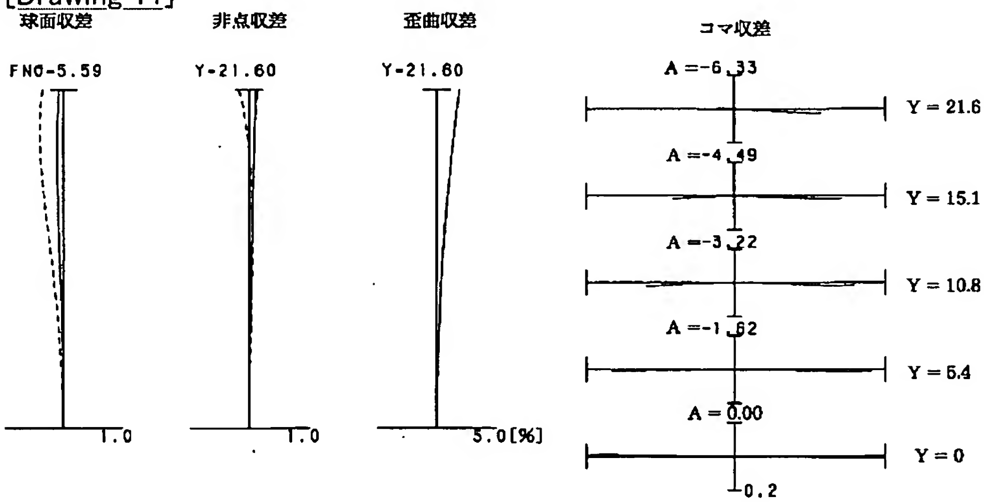
[Drawing 9]



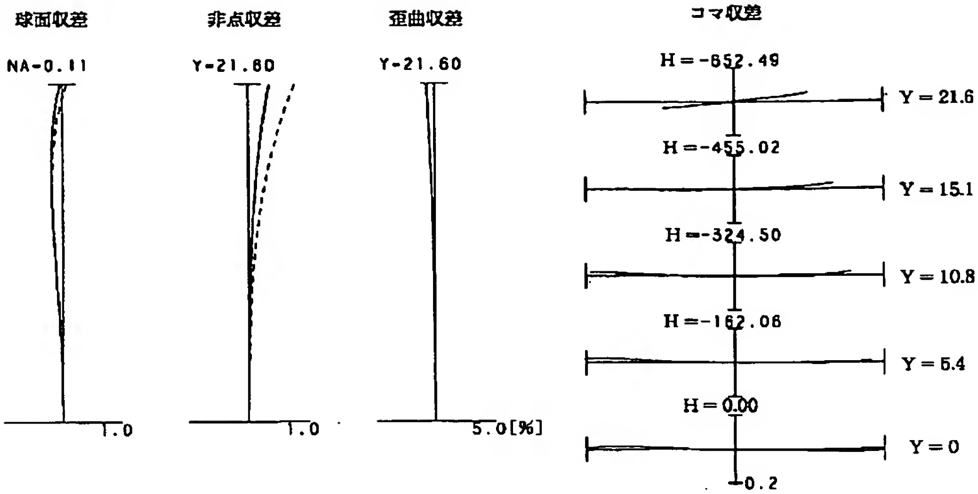
[Drawing 10]



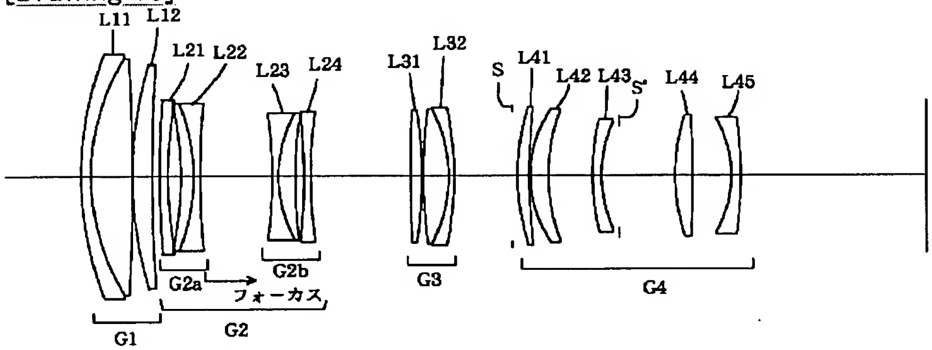
[Drawing 11]



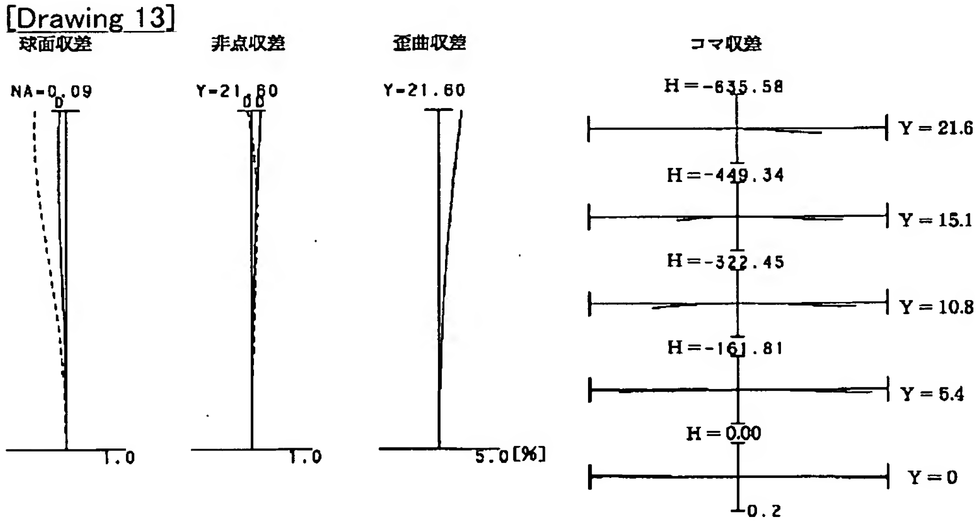
[Drawing 12]



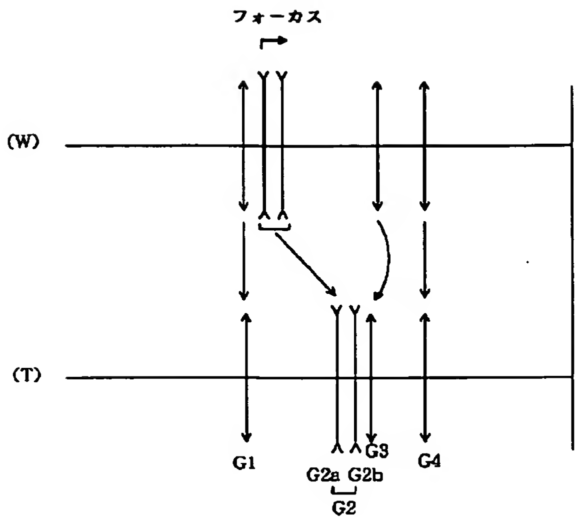
[Drawing 15]



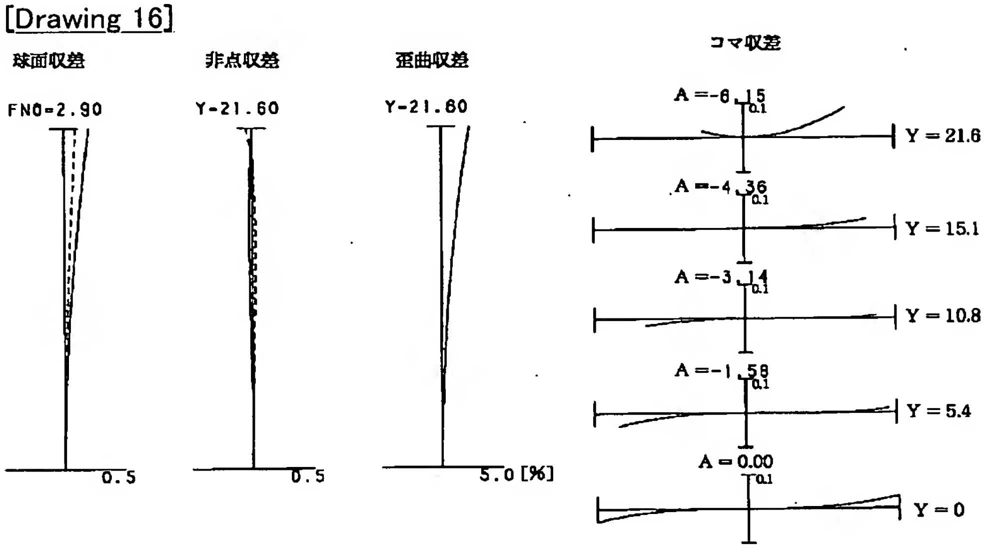
[Drawing 13]



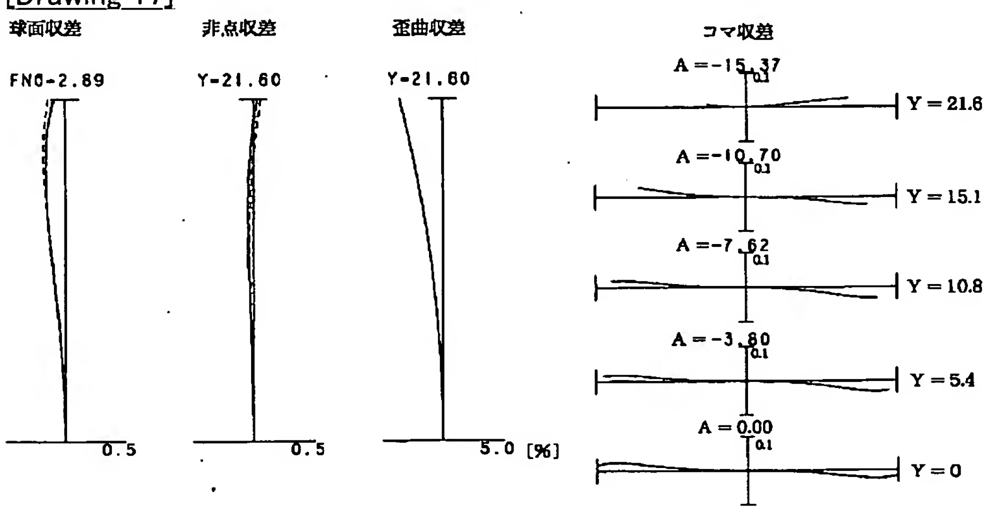
[Drawing 14]



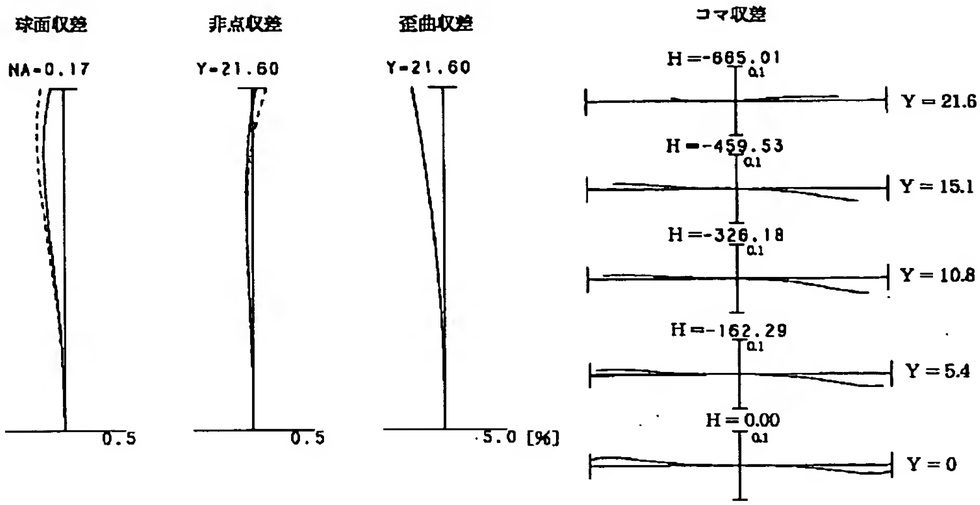
[Drawing 16]



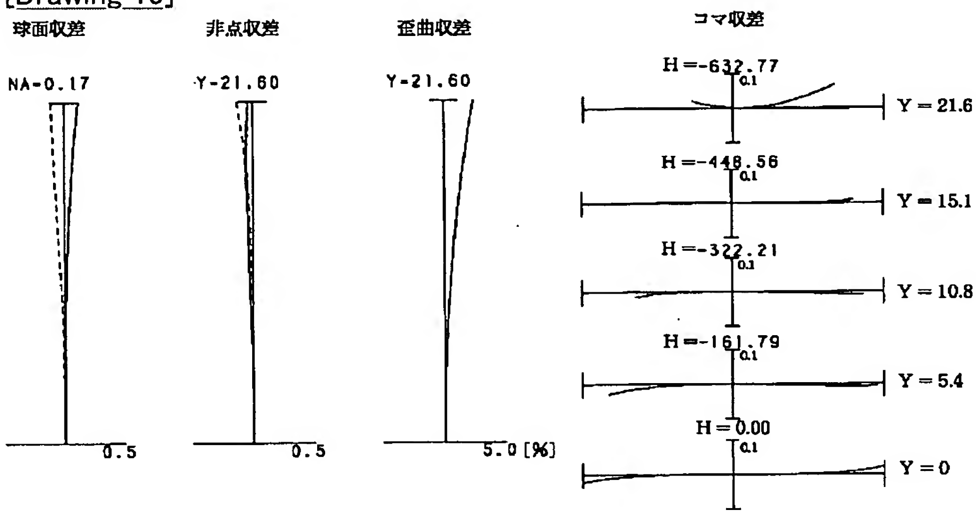
[Drawing 17]



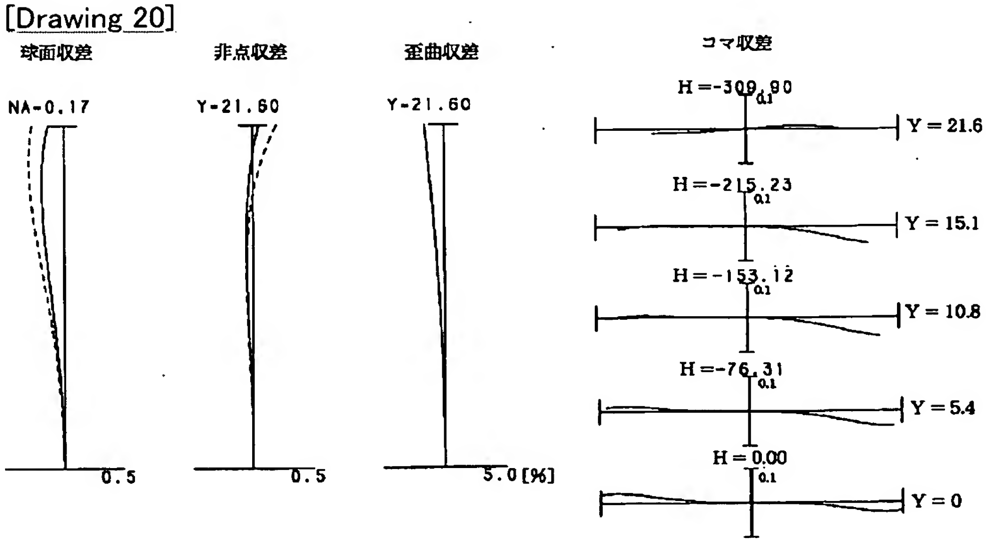
[Drawing 18]



[Drawing 19]



[Drawing 20]



[Drawing 21]

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平8－220438

(43)公開日　平成８年(1996)８月30日

(51)Int.Cl.⁶	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｇ０２Ｂ　15/20			Ｇ０２Ｂ　15/20	

審査請求　未請求　請求項の数５　ＦＤ　（全 18 頁）

(21)出願番号　特願平7－53578

(22)出願日　平成７年(1995)２月17日

(71)出願人　000004112
株式会社ニコン
東京都千代田区丸の内３丁目２番３号

(72)発明者　大竹　基之
東京都品川区西大井１丁目６番３号　株式会社ニコン大井製作所内

(72)発明者　鈴木　憲三郎
東京都品川区西大井１丁目６番３号　株式会社ニコン大井製作所内

(74)代理人　弁理士　山口　孝雄

(54)【発明の名称】　近距離合焦可能なズームレンズ

(57)【要約】

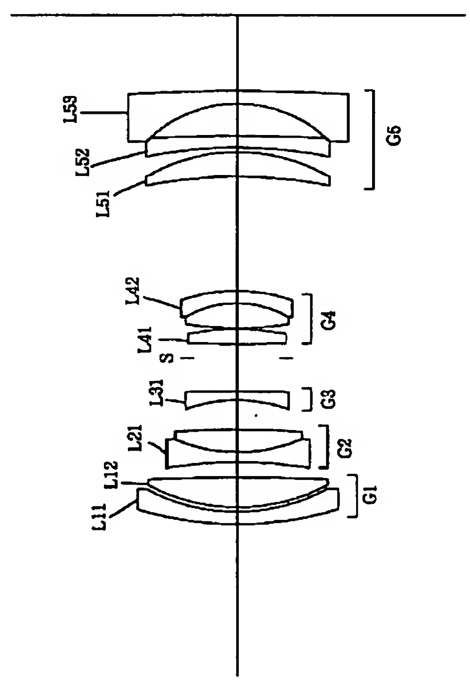
【目的】　少ない移動量でフォーカシングが可能であり、且つ結像性能の優れた近距離合焦可能なズームレンズを提供すること。

【構成】　本発明では、互いに隣接して配置され且つともに負の屈折力を有する２つのレンズ群を少なくとも備えた近距離合焦可能なズームレンズにおいて、前記２つのレンズ群のうち変倍に際して可動のレンズ群Ｇａを光軸に沿って移動させて近距離物体への合焦を行い、前記レンズ群Ｇａの無限遠合焦状態での望遠端における使用倍率をβａとし、前記レンズ群Ｇａの無限遠合焦状態での広角端における使用倍率をβｂとしたとき、

$(\beta a-\beta a^{-1})^{-2}<0.8$

$\beta a/\beta b>0$

の条件を満足する。



1

【特許請求の範囲】

【請求項1】　互いに隣接して配置され且つともに負の屈折力を有する２つのレンズ群を少なくとも備えた近距離合焦可能なズームレンズにおいて、

前記２つのレンズ群のうち変倍に際して可動のレンズ群Ｇａを光軸に沿って移動させて近距離物体への合焦を行い、

前記レンズ群Ｇａの無限遠合焦状態での望遠端における使用倍率をβａとし、前記レンズ群Ｇａの無限遠合焦状態での広角端における使用倍率をβｂとしたとき、

$(\beta a-\beta a^{-1})^{-2}<0.8$

$\beta a/\beta b>0$

の条件を満足することを特徴とする近距離合焦可能なズームレンズ。

【請求項2】　前記レンズ群Ｇａの焦点距離をｆａとし、広角端におけるレンズ系全体の焦点距離をｆｗとし、望遠端におけるレンズ系全体の焦点距離をｆｔとしたとき、

$0.12<|fa|/(fw\cdot ft)^{1/2}<0.6$

の条件を満足することを特徴とする請求項１に記載の近距離合焦可能なズームレンズ。

【請求項3】　最も物体側には正の屈折力を有する第１レンズ群Ｇ１が配置され、前記２つのレンズ群は前記第１レンズ群Ｇ１の像側に隣接して配置されていることを特徴とする請求項１または２に記載の近距離合焦可能なズームレンズ。

【請求項4】　前記２つのレンズ群のうち物体側のレンズ群の焦点距離をｆL1とし、前記２つのレンズ群のうち像側のレンズ群の焦点距離をｆL2としたとき、

$0.3<fL1/fL2<5.0$

の条件を満足することを特徴とする請求項１乃至３のいずれか１項に記載の近距離合焦可能なズームレンズ。

【請求項5】　前記レンズ群Ｇａ中に含まれるすべての負レンズ成分のアッベ数のうち最大の値をνGaとし、前記レンズ群Ｇａ中に含まれるすべての負レンズ成分の屈折率のうち最大の値をnGaとしたとき、

$\nu Ga>35$

$nGa>1.60$

の条件を満足することを特徴とする請求項１乃至４のいずれか１項に記載の近距離合焦可能なズームレンズ。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、近距離合焦可能なズームレンズに関し、特に口径比が２．８程度の明るいズームレンズにも適用可能なズームレンズに関する。

【0002】

【従来の技術】最近のカメラにおける傾向として、①撮影レンズはズームレンズが主流となりつつあること、および②オートフォーカスが可能なカメラが増えていることの２点が挙げられる。

2

【0003】ズームレンズが主流になるにつれ、高変倍化や高性能化を図った種々のズームタイプが提案されてきている。また、近年の鏡筒技術の進歩等により、３群以上の可動レンズ群により構成される、いわゆる多群ズームレンズを用いて高変倍化を図ったズームタイプが種々提案されている。また、オートフォーカスが可能なカメラでは、フォーカシング（合焦）動作の高速化が進んでいる。そして、フォーカシング動作の高速化に伴って、多群ズームレンズにおけるフォーカシング方法に関しても種々の方法が提案されている。

【0004】

【発明が解決しようとする課題】一般的に、フォーカシング動作の高速化を図るために、フォーカシングレンズ群（フォーカシング時に光軸に沿って移動するレンズ群）に要求されることは、フォーカシング時の仕事量（＝重量×移動量）を小さくすることである。しかしながら、従来のズームレンズにおいては、フォーカシング時の仕事量が充分小さくないという不都合があった。

【0005】本発明は、前述の課題に鑑みてなされたものであり、少ない移動量でフォーカシングが可能であり、且つ結像性能の優れた近距離合焦可能なズームレンズを提供することを目的とする。

【0006】

【課題を解決するための手段】前記課題を解決するために、本発明においては、互いに隣接して配置され且つともに負の屈折力を有する２つのレンズ群を少なくとも備えた近距離合焦可能なズームレンズにおいて、前記２つのレンズ群のうち変倍に際して可動のレンズ群Ｇａを光軸に沿って移動させて近距離物体への合焦を行い、前記レンズ群Ｇａの無限遠合焦状態での望遠端における使用倍率をβａとし、前記レンズ群Ｇａの無限遠合焦状態での広角端における使用倍率をβｂとしたとき、

$(\beta a-\beta a^{-1})^{-2}<0.8$

$\beta a/\beta b>0$

の条件を満足することを特徴とする近距離合焦可能なズームレンズを提供する。

【0007】本発明の好ましい態様によれば、前記レンズ群Ｇａの焦点距離をｆａとし、広角端におけるレンズ系全体の焦点距離をｆｗとし、望遠端におけるレンズ系全体の焦点距離をｆｔとしたとき、

$0.12<|fa|/(fw\cdot ft)^{1/2}<0.6$

の条件を満足する。

【0008】

【作用】まず、３群以上の可動レンズ群により構成される、いわゆる多群ズームレンズに関する一般論を述べる。多群ズームレンズにおいては、広角端から望遠端への変倍に際する各レンズ群のズーミング軌道に選択の自由度が増えるため、収差補正上の自由度が多くなる。また、変倍を担うレンズ群が増えるため、各レンズ群の変倍負担の均等化がし易くなる。こうして、高変倍化を図

3　4

りつつ高性能化を図ることが可能となる。なお、可動部分の増加に伴う鏡筒構造の複雑化等の問題もあったが、近年の鏡筒技術の進歩によりある程度克服されている。

【0009】次に、多群ズームレンズにおけるフォーカシングに関して述べる。一般的に、フォーカシングレンズ群に要求されることは、前述のように、フォーカシング移動量が少ないこと、およびフォーカシングレンズ群の重量が小さいことである。これは、フォーカシング移動量が少ないほどレンズ系の小型化につなげることができ、フォーカシングレンズ群の重量が小さいほどレンズの駆動機構の簡略化を図ることができるためである。

【0010】従来より、多群ズームレンズにおいて近距離物体に対する合焦を行なう場合、次の３つの方式に関して種々の提案がなされている。

（A）　１群繰り出し方式

（B）　ＩＦ（インナー・フォーカス）方式

（C）　ＲＦ（リア・フォーカス）方式

【0011】従来より、たとえば物体側から順に正負正正の４群ズームレンズでは、（A）の１群繰り出し方式が用いられる。しかしながら、第１レンズ群は像面から最も離れて配置されているため、レンズ径が大きい。その結果、第１レンズ群はフォーカシングレンズ群にはあまり適していない。また、本出願人による特開平５－２２４１２３号公報には、物体側から順に正負負正負の５群ズームレンズにおいて、変倍中固定の第２レンズ群を移動させて（B）のインナー・フォーカス方式のフォーカシングを行なう例が開示されている。しかしながら、＊第２レンズ群が変倍中固定であるため、第２レンズ群を積極的に変倍作用に寄与させることができず、高性能化の点で充分といえない。

【0012】さらに、特開昭６１－５０１１２号公報には、物体側から順に正負正負の４群ズームレンズの第４レンズ群を移動させて（C）のリア・フォーカス方式のフォーカシングを行なう例が開示されている。しかしながら、第４レンズ群はそのレンズ径が大きいので、フォーカシングレンズ群にはあまり適していない。

【0013】ここで、１つのレンズ群を移動させてフォーカシングを行なう際のフォーカシングレンズ群の移動に関して述べる。被写体の位置が遠距離から近距離に移動するとき、フォーカシングレンズ群Ｇｆの像側に配置されたレンズ群Ｇｈに対する第１レンズ群Ｇ１乃至フォーカシングレンズ群Ｇｆによる物点の位置が一定となるように、フォーカシングレンズ群Ｇｆを移動させれば、近距離合焦を行うことができる。この際、フォーカシングレンズ群Ｇｆの移動量Δを小さくする条件について薄肉レンズ系を用いて説明する。

【0014】まず、図１に示すように、フォーカシングレンズ群Ｇｆに対する物点の位置がδだけ移動するとき、レンズ群Ｇｈに対する物点の位置を一定にするために、レンズ群ＧｆをΔだけ移動させるものとする。この場合、レンズ群Ｇｆの結像倍率をβとすると、フォーカシングレンズ群Ｇｆの移動量Δは、次の数式（a）で与えられる。

$$\Delta=[\beta^2/(\beta^2-1)]\cdot\delta \qquad (a)$$

【0015】（a）式において、$k=\beta^2/(\beta^2-1)$とすると、ｋの値はβ^2の値に依存して次の式※（b）および（c）で表すようになる。

$$k\geqq 1 \quad (\beta^2>1) \qquad (b)$$

$$k<0 \quad (\beta^2<1) \qquad (c)$$

【0016】したがって、レンズ群Ｇｆの移動量Δの大きさを小さくするには、（b）の場合にはｋをできるだけ１に近づける、すなわち１／βを０に近づけることが必要であり、（c）の場合には、ｋをできるだけ０に近づける、すなわちβを０に近づけることが必要である。

【0017】以上の考察に基づき、本発明においては、互いに隣接して配置され且つともに負の屈折力を有する２つのレンズ群を少なくとも有するズームレンズにおいて、この２つのレンズ群のうち物体側に配置されたレンズ群の使用倍率の逆数を０に近づけるとともに、像側に配置されたレンズ群の使用倍率を０に近づけることにより、上述の２つのレンズ群のうちいずれのレンズ群をフォーカシング時に移動させてもそのフォーカシング移動量を小さくすることができる。本発明においては、各レ★ンズ群の変倍の負担の平均化を図って高変倍化につなげるために、２つのレンズ群のうち変倍時に可動であるレンズ群Ｇａをフォーカシング時に移動させている。

【0018】本発明は、以上のような技術的背景に基づいてなされたものであり、隣接して配置される２つのレンズ群が共に負の屈折力を有するような近距離合焦可能なズームレンズにおいて、２つのレンズ群のうち変倍に際して可動のレンズ群Ｇａを移動させて近距離物体へのフォーカシングを行うとともに所定の条件を満たすことにより、前述の課題の解決を図るものである。

【0019】以下、本発明の各条件式について説明する。本発明のズームレンズでは、次の条件式（1）および（2）を満足する。

$$(\beta a-\beta a^{-1})^{-2}<0.8 \qquad (1)$$

$$\beta a/\beta b>0 \qquad (2)$$

ここで、

βａ：レンズ群Ｇａの無限遠合焦状態での望遠端における使用倍率

βｂ：レンズ群Ｇａの無限遠合焦状態での広角端におけ

る使用倍率

【0020】条件式（1）は、フォーカシングレンズ群Ｇａの望遠端における使用倍率を規定する条件式である。前述のように、レンズ群Ｇａのフォーカシング移動量（フォーカシングに際する移動量）Δは式（ａ）で表され、ｋの大きさを小さくすることによりレンズ群Ｇａのフォーカシング移動量Δを小さくすることができる。

【0021】なお、条件式（1）は、変形することにより（ｋ／β）² と表される。すなわち、条件式（1）では、ｋとβとの比を２乗することにより、ｋの大きさを小さくすることによりレンズ群Ｇａのフォーカシング移動量Δを小さくする本発明の特徴を強調している。条件式（1）の上限値を上回った場合、レンズ群Ｇａのフォーカシング移動量が大きくなってしまう。なお、本発明において、レンズ群Ｇａのフォーカシング移動量をさらに小さく抑えるには、条件式（1）の上限値を０．５とすることが望ましい。

【0022】前述のように、$\beta^2>1$の場合、１／βを０に近づけると少ない移動量でフォーカシングを行うことができる。しかしながら、広角端から望遠端までの変倍中に、１／β＝０となる位置が存在すると、広角端から１／β＝０の位置まではｋが減少し、１／β＝０の位置から望遠端まではｋが増大するので、レンズ群Ｇａの制御が難しくなってしまう。また、$\beta^2<1$の場合、βを０に近づけると少ない移動量でフォーカシングを行うことができる。しかしながら、広角端から望遠端までの変倍中に、β＝０となる位置が存在すると、広角端からβ＝０の位置まではｋが減少し、β＝０の位置から望遠端まではｋが増大するので、レンズ群Ｇａの制御が難しくなってしまう。

【0023】条件式（2）は、望遠端におけるレンズ群Ｇａの使用倍率βａと広角端におけるレンズ群Ｇａの使用倍率βｂとの比について適切な範囲を規定している。条件式（2）の下限値を下回った場合、広角端から望遠端までの変倍中に、１／βあるいはβが０になる位置を含んでしまう。このため、前述したように、レンズ群Ｇａの制御が難しくなってしまう。特に、同じ撮影距離に対する繰り出し量が、広角端から望遠端に変倍するにしたがって、一度減少して、途中から増大する。このため、フォーカシングレンズ群を位置制御することが難しくなってしまう。

【0024】また、本発明においては、さらに高性能化を図るために、以下の条件式（3）を満足することが望ましい。

$$0.12<|fa|/(fw\cdot ft)^{1/2}<0.6 \qquad (3)$$

ここで、

ｆａ：レンズ群Ｇａの焦点距離

ｆｗ：広角端におけるレンズ系全体の焦点距離

ｆｔ：望遠端におけるレンズ系全体の焦点距離

【0025】条件式（3）はレンズ群Ｇａの焦点距離を規定しており、レンズ群Ｇａのフォーカシング移動量をさらに小さくすることとレンズ群Ｇａの構成レンズ枚数を少なくすることとのバランスを図るための条件式である。条件式（3）の上限値を上回った場合、レンズ群Ｇａの焦点距離が負に大きくなるため、レンズ群Ｇａのフォーカシング移動量が大きくなってしまう。

【0026】逆に、条件式（3）の下限値を下回った場合、レンズ群Ｇａの焦点距離が負に小さくなるため、レンズ群Ｇａのフォーカシング移動量を小さくすることができる。しかしながら、レンズ群Ｇａを通過する軸外光束が光軸に近づくため、軸上収差と軸外収差とを少ないレンズ枚数で独立に補正することが困難となってしまう。その結果、フォーカシング時の仕事量を小さくすることができない。

【0027】本発明においては、レンズ系の最も物体側に正屈折力を有する第１レンズ群Ｇ１を配置し、負屈折力を有する当該２つのレンズ群を第１レンズ群Ｇ１の像側に隣接して配置することにより、さらに高変倍化と高性能化とを図ることができる。なお、本発明においては、広角端におけるレンズ群Ｇａの使用倍率βｂが条件式（1）と同様な次の条件式（4）を満足するように構成することにより、変倍範囲の全体に亘ってレンズ群Ｇａのフォーカシング移動量を小さくすることも可能である。

$$(\beta b-\beta b^{-1})^{-2}<0.8 \qquad (4)$$

【0028】また、本発明においては、以下の条件式（5）を満足することが望ましい。

$$0.3<fL1/fL2<5.0 \qquad (5)$$

ここで、

ｆL1：当該２つの負レンズ群のうち物体側のレンズ群の焦点距離

ｆL2：当該２つの負レンズ群のうち像側のレンズ群の焦点距離

【0029】条件式（5）は、ズームレンズ中において隣接して配置された当該２つの負レンズ群の焦点距離のバランスを図るための条件式である。条件式（5）の上限値および下限値で規定される範囲を逸脱すると、変倍時に発生する諸収差の変動とフォーカシング時に発生する諸収差の変動とを同時に良好に抑えることができなくなってしまう。

【0030】また、フォーカシング時に発生する色収差の変動をさらに良く抑えるには、レンズ群Ｇａにおいて色収差を充分良好に補正することが望ましい。このため、レンズ群Ｇａ中に含まれるすべての負レンズ成分のアッベ数のうち最大の値νGaは、以下の条件式（6）を満足することが望ましい。

νGa＞35 (6)

また、コマ収差の発生を抑えてさらに良好な結像性能を得るには、レンズ群Ga中に含まれるすべての負レンズ＊成分の屈折率のうち最大の値nGaは、以下の条件式（7）を満足することが望ましい。

nGa＞1．60 (7)

【0031】また、本発明においては、ズームレンズを構成するいずれかのレンズ群に少なくとも1つの非球面を導入することにより、さらに高性能化や高変倍化、あるいは大口径化を図ることが容易になる。さらに、1つまたは複数のレンズ群を光軸とほぼ直交する方向に移動させて像シフトさせることが可能であるが、像シフト時にも良好な結像性能を得ることも可能である。

【0032】

【実施例】以下、本発明の各実施例を、添付図面に基づいて説明する。

〔実施例1〕図2は、本発明の第1実施例にかかるズームレンズの屈折力配置図である。図2のズームレンズは、物体側から順に、正屈折力の第1レンズ群G1と、負屈折力の第2レンズ群G2と、負屈折力の第3レンズ群G3と、正屈折力の第4レンズ群G4と、負屈折力の第5レンズ群G5とを備え、広角端（W）から望遠端（T）への変倍に際して、第1レンズ群G1と第2レンズ群G2との間隔は増大し、第2レンズ群G2と第3レンズ群G3との間隔は増大し、第3レンズ群G3と第4レンズ群G4との間隔は減少し、第4レンズ群G4と第5レンズ群G5との間隔は減少するように、各レンズ群が物体側に移動する。なお、第3レンズ群G3を光軸に沿って移動させることにより、近距離物体へのフォーカシングを行う。

【0033】図3は、本発明の第1実施例にかかるズームレンズのレンズ構成を示す図である。図3のズームレンズは、物体側から順に、物体側に凸面を向けた負メニスカスレンズL11、および両凸レンズL12からなる第1レンズ群G1と、両凹レンズと両凸レンズとの接合負レンズL21からなる第2レンズ群G2と、物体側に凹面を向けた負メニスカスレンズL31からなる第3レンズ群G3と、両凸レンズL41、および両凸レンズと物体側に凹面を向けた負メニスカスレンズとの接合正レンズL42からなる第4レンズ群G4と、物体側に凹面を向けた正メニスカスレンズL51、物体側に凹面を向けた負メニスカスレンズL52、および物体側に凹面を向けた負メニスカスレンズL53からなる第5レンズ群G5とから構成されている。

【0034】なお、開口絞りSは、第3レンズ群G3と第4レンズ群G4との間に配置され、広角端から望遠端への変倍に際して第4レンズ群G4と一体的に移動する。図3は、広角端における各レンズ群の位置関係を示しており、望遠端への変倍時には図2に矢印で示すズーム軌道に沿って光軸上を移動する。

【0035】次の表（1）に、本発明の実施例1の諸元の値を掲げる。表（1）において、fは焦点距離を、FNOはFナンバーを、2ωは画角を、Bfはバックフォーカスを表す。さらに、面番号は光線の進行する方向に沿った物体側からのレンズ面の順序を、屈折率およびアッベ数はそれぞれd線（λ＝587．6nm）に対する値を示している。

【0036】

【表1】

f＝38.8～110.5

FNO＝4.1 ～ 8.0

2ω＝57.8° ～21.4°

面番号	曲率半径	面間隔	屈折率	アッベ数
1	38.7385	1.633	1.80518	25.35
2	21.3035	0.628		
3	21.0319	3.893	1.62280	57.03
4	-341.0792	(d4= 可変)		
5	-51.9442	1.256	1.77279	49.45
6	17.0448	2.888	1.75520	27.61
7	-133.8779	(d7= 可変)		
8	-19.9515	1.256	1.77279	49.45
9	-151.1844	(d9= 可変)		
10	∞	1.884	(開口絞りS)	
11	89.4983	2.009	1.62041	60.14
12	-28.8833	0.126		
13	44.5675	3.391	1.51860	69.98
14	-11.5129	1.507	1.80518	25.35
15	-20.3434	(d15=可変)		

16	-54.3667	3.140	1.80518	25.35
17	-21.7045	0.628		
18	-48.6549	1.507	1.84042	43.35
19	-141.6808	4.144		
20	-14.7784	1.507	1.77279	49.45
21	-280.6453	(Bf)		

（変倍における可変間隔）

f	38.7626	110.4625
d4	1.9829	15.1690
d7	3.7630	6.2747
d9	4.1545	1.6429
d15	14.9653	1.7792
Bf	10.0151	51.8560

（撮影倍率－１／４０倍時の第３レンズ群Ｇ３のフォーカシング移動量）

焦点距離	f	38.7626	110.4625
移動量	Δ	-1.0496	-1.1477

（ただし、フォーカシング移動量Δの符号は、光線の進行方向を正とする）

（条件対応値）

$f\,a=-29.8672$

$f\,L1=-99.2862$

$f\,L2=-29.8672$

$\beta\,a=-0.4612$

$\beta\,b=-0.2080$

（１）$(\beta a-\beta a^{-1})^{-2}$ ＝ ０．３４３

（２）$\beta a/\beta b$ ＝ ２．２１７

（３）$|fa|/(fw\cdot ft)^{1/2}$ ＝ ０．２０８

（４）$(\beta b-\beta b^{-1})^{-2}$ ＝ ０．０４７

（５）$fL1/fL2$ ＝ ３．３２４

（６）νGa ＝４９．４５

（７）nGa ＝ １．７７２７９

【００３７】図４乃至図７は実施例１のｄ線（λ＝５８７．６ｎｍ）に対する諸収差図である。図４は広角端（最短焦点距離状態）での無限遠合焦状態における諸収差図であり、図５は望遠端（最長焦点距離状態）での無限遠合焦状態における諸収差図である。一方、図６は広角端での撮影倍率－１／４０の合焦状態における諸収差図であり、図７は望遠端での撮影倍率－１／４０の合焦状態における諸収差図である。

【００３８】各収差図において、FNOはＦナンバーを、ＮＡは開口数を、Ｙは像高を、Ａは各像高に対する画角を、Ｈは各像高に対する物体高をそれぞれ示している。また、非点収差を示す収差図において実線はサジタル像面を示し、破線はメリディオナル像面を示している。さらに、球面収差を示す収差図において破線はサインコンディション（正弦条件）を示している。各収差図から明らかなように、本実施例では、各焦点距離状態において無限遠合焦状態から近距離合焦状態に亘り諸収差が良好に補正されていることがわかる。

【００３９】〔実施例２〕図８は、本発明の第２実施例にかかるズームレンズの屈折力配置図である。図８のズームレンズは、物体側から順に、正屈折力の第１レンズ群Ｇ１と、負屈折力の第２レンズ群Ｇ２と、正屈折力の第３レンズ群Ｇ３とを備え、広角端（W）から望遠端（T）への変倍に際して、第１レンズ群Ｇ１と第２レンズ群Ｇ２との間隔は増大し、第２レンズ群Ｇ２と第３レンズ群Ｇ３との間隔は減少するように、各レンズ群が物体側に移動する。なお、第２レンズ群Ｇ２は、物体側の負屈折力を有するレンズ群G2aと像側の負屈折力を有するレンズ群G2bとからなり、物体側のレンズ群G2aを光軸に沿って移動させることにより、近距離物体へのフォーカシングを行う。

【００４０】図９は、本発明の第２実施例にかかるズームレンズのレンズ構成を示す図である。図９のズームレンズは、物体側から順に、両凸レンズＬ１１、および物体側に凸面を向けた負メニスカスレンズと両凸レンズとの接合正レンズＬ１２からなる第１レンズ群Ｇ１と、両凹レンズと物体側に凸面を向けた正メニスカスレンズとの接合負レンズＬ２１からなるレンズ群G2a、および物

体側に凹面を向けた負メニスカスレンズＬ２２からなるレンズ群G2bからなる第２レンズ群Ｇ２と、両凸レンズＬ３１、両凸レンズと物体側に凹面を向けた負メニスカスレンズとの接合正レンズＬ３２、物体側に凸面を向けた正メニスカスレンズＬ３３、物体側に凹面を向けた負メニスカスレンズＬ３４、および物体側に凹面を向けた正メニスカスレンズＬ３５からなる第３レンズ群Ｇ３とから構成されている。

【００４１】なお、開口絞りＳは、第３レンズ群Ｇ３中の正メニスカスレンズＬ３３と負メニスカスレンズＬ３４との間に配置され、広角端から望遠端への変倍に際して第３レンズ群Ｇ３と一体的に移動する。また、開口絞りＳの像側には、図示のように固定絞りＳ’が配置されている。図９は、広角端における各レンズ群の位置関係を示しており、望遠端への変倍時には図８に矢印で示すズーム軌道に沿って光軸上を移動する。

【００４２】次の表（２）に、本発明の実施例２の諸元の値を掲げる。表（２）において、ｆは焦点距離を、FNOはＦナンバーを、２ωは画角を、Ｂｆはバックフォーカスを表す。さらに、面番号は光線の進行する方向に沿った物体側からのレンズ面の順序を、屈折率およびアッベ数はそれぞれｄ線（λ＝５８７．６ｎｍ）に対する値を示している。

【００４３】

【表２】

ｆ＝85.5～191.0
FNO＝4.7 ～ 5.6
２ω＝29.0°～12.7°

面番号	曲率半径	面間隔	屈折率	アッベ数
1	132.8387	4.000	1.51680	64.12
2	3064.5789	0.115		
3	88.6525	2.000	1.80458	25.49
4	50.6836	5.000	1.51680	64.12
5	-399.3308	(d5= 可変)		
6	-140.8889	1.200	1.69680	55.60
7	23.1440	3.500	1.84666	23.82
8	50.7877	13.000		
9	-45.6950	1.000	1.65160	58.54
10	-996.6611	(d10=可変)		
11	106.2788	5.175	1.50137	56.46
12	-48.1738	0.230		
13	84.4967	6.095	1.51860	70.08
14	-36.8350	1.610	1.75520	27.64
15	-642.3547	0.920		
16	32.6932	4.140	1.71300	53.97
17	52.1070	3.220		
18	∞	22.310	（開口絞りＳ）	
19	∞	20.700	（固定絞りＳ’）	
20	-18.8960	2.415	1.76684	46.76
21	-53.3018	0.230		
22	-227.2534	3.220	1.72825	28.34
23	-37.5483	(Bf)		

（変倍における可変間隔）

f	85.5000	191.0000
d5	1.4053	33.1577
d10	21.6093	5.5585
Bf	45.9663	62.0168

（撮影倍率－１／３０倍時のレンズ群G2aのフォーカシング移動量）

焦点距離	f	85.5000	191.0000
移動量	Δ	+8.4418	+2.5356

（ただし、フォーカシング移動量Δの符号は、光線の進行方向を正とする）

（条件対応値）

f a=-66.1034
fL1=-73.5277
fL2=-66.1034
β a= -5.7383
β b= -1.5276

(1)　$(\beta a-\beta a^{-1})^{-2}$　＝　０．０３２
(2)　$\beta a/\beta b$　＝　３．７５６
(3)　$|fa|/(fw\cdot ft)^{1/2}$　＝　０．２６８
(4)　$(\beta b-\beta b^{-1})^{-2}$　＝　１．３１２
(5)　fL1／fL2　＝　１．１１２
(6)　νGa　＝５５．６０
(7)　nGa　＝　１．６９６８０

【００４４】図１０乃至図１３は実施例２のｄ線（λ＝５８７．６ｎｍ）に対する諸収差図である。図１０は広角端での無限遠合焦状態における諸収差図であり、図１１は望遠端での無限遠合焦状態における諸収差図である。一方、図１２は広角端での撮影倍率－１／３０の合焦状態における諸収差図であり、図１３は望遠端での撮影倍率－１／３０の合焦状態における諸収差図である。

【００４５】各収差図において、FNOはＦナンバーを、ＮＡは開口数を、Ｙは像高を、Ａは各像高に対する画角を、Ｈは各像高に対する物体高をそれぞれ示している。また、非点収差を示す収差図において実線はサジタル像面を示し、破線はメリディオナル像面を示している。さらに、球面収差を示す収差図において破線はサインコンディション（正弦条件）を示している。各収差図から明らかなように、本実施例では、各焦点距離状態において無限遠合焦状態から近距離合焦状態に亘り諸収差が良好に補正されていることがわかる。

【００４６】〔実施例３〕図１４は、本発明の第３実施例にかかるズームレンズの屈折力配置図である。図１４のズームレンズは、物体側から順に、正屈折力の第１レンズ群Ｇ１と、負屈折力の第２レンズ群Ｇ２と、正屈折力の第３レンズ群Ｇ３と、正屈折力の第４レンズ群Ｇ４とを備え、広角端（Ｗ）から望遠端（Ｔ）への変倍に際して、第１レンズ群Ｇ１と第２レンズ群Ｇ２との間隔は増大し、第２レンズ群Ｇ２と第３レンズ群Ｇ３との間隔は減少し、第２レンズ群Ｇ３と第３レンズ群Ｇ４との間隔は変化するように、第２レンズ群Ｇ２および第３レンズ群Ｇ３が移動する。なお、第２レンズ群Ｇ２は、物体側の負屈折力を有するレンズ群G2aと像側の負屈折力を有するレンズ群G2bとからなり、物体側のレンズ群G2aを光軸に沿って移動させることにより、近距離物体へのフォーカシングを行う。

【００４７】図１５は、本発明の第３実施例にかかるズームレンズのレンズ構成を示す図である。図１５のズームレンズは、物体側から順に、物体側に凸面を向けた負メニスカスレンズと両凸レンズとの接合レンズＬ１１、および物体側に凸面を向けた正メニスカスレンズＬ１２からなる第１レンズ群Ｇ１と、物体側に凸面を向けた負メニスカスレンズＬ２１および物体側に凹面を向けた接合面を有する両凹レンズ形状の接合レンズＬ２２からなるレンズ群G2a、および物体側に凸面を向けた接合面を有する両凹レンズ形状の接合レンズＬ２３および両凹レンズＬ２４からなるレンズ群G2bからなる第２レンズ群Ｇ２と、両凸レンズＬ３１、両凸レンズと物体側に凹面を向けた負メニスカスレンズとの接合正レンズＬ３２からなる第３レンズ群Ｇ３と、物体側に凸面を向けた正メニスカスレンズＬ４１、物体側に凸面を向けた正メニスカスレンズＬ４２、物体側に凸面を向けた負メニスカスレンズＬ４３、両凸レンズＬ４４、および物体側に凹面を向けた負メニスカスレンズＬ４５からなる第４レンズ群Ｇ４とから構成されている。

【００４８】なお、開口絞りＳは、第３レンズ群Ｇ３と第４レンズ群Ｇ４との間に配置され、広角端から望遠端への変倍に際して第４レンズ群Ｇ４と一体的に移動する。また、第４レンズ群Ｇ４中には、図示のように固定絞りＳ’が配置されている。図１５は、広角端における各レンズ群の位置関係を示しており、望遠端への変倍時には図１４に矢印で示すズーム軌道に沿って第２レンズ群Ｇ２および第３レンズ群Ｇ３が光軸上を移動する。ただし、第１レンズ群Ｇ１および第４レンズ群Ｇ４は、変倍中光軸に沿って固定である。

【００４９】次の表（３）に、本発明の実施例３の諸元の値を掲げる。表（３）において、ｆは焦点距離を、FNOはＦナンバーを、２ωは画角を、Ｂｆはバックフォーカスを表す。さらに、面番号は光線の進行する方向に沿った物体側からのレンズ面の順序を、屈折率およびアッベ数はそれぞれｄ線（λ＝５８７．６ｎｍ）に対する値を示している。

【００５０】

【表３】

f＝81.5～196.0
FNO＝2.8 ～2.8
2ω＝30.7～18.1°

面番号	曲率半径	面間隔	屈折率	アッベ数
1	105.5399	2.800	1.80458	25.50
2	73.4058	11.400	1.49782	82.52
3	-570.0625	0.100		
4	118.0775	5.700	1.49782	82.52
5	1042.0722	(d5= 可変)		
6	322.9129	2.100	1.74810	52.30
7	122.5766	3.850		
8	-118.7333	3.500	1.80458	25.50
9	-61.4330	1.600	1.56384	60.69
10	262.6263	19.631		
11	-119.9235	1.500	1.58130	61.09
12	42.1223	4.500	1.80458	25.50
13	118.0410	2.400		
14	-181.3955	1.800	1.79668	45.37
15	139.1660	(d15=可変)		
16	302.2780	3.300	1.58270	46.42
17	-143.1744	0.100		
18	143.7170	6.900	1.51860	69.98
19	-49.9410	1.600	1.80458	25.50
20	-113.3388	(d20=可変)		
21	∞	1.500	(開口絞りＳ)	
22	65.9782	3.100	1.49782	82.52
23	163.6723	0.100		
24	37.7279	5.200	1.49782	82.52
25	67.7955	11.682		
26	79.1100	2.400	1.80458	25.50
27	46.4525	4.942		
28	∞	15.500	(固定絞りＳ’)	
29	65.3317	4.800	1.79613	40.90
30	-244.7240	10.475		
31	-38.3284	2.500	1.77279	49.45
32	-122.1555	(Bf)		

(変倍における可変間隔)

f	81.5039	196.0000
d5	1.9240	38.1174
d15	27.2250	2.3519
d20	15.6184	4.2981
Bf	50.6056	50.6056

(撮影倍率－１／３０倍時のレンズ群Ｇ2aのフォーカシング移動量)

焦点距離	f	81.5039	196.0000
移動量	Δ	+6.4919	+4.1781

(ただし、フォーカシング移動量Δの符号は、光線の進行方向を正とする)

(撮影距離１．５ｍ時のレンズ群Ｇ2aのフォーカシング移動量)

焦点距離	f	81.5039	196.0000
移動量	Δ	13.8134	15.6683

(ただし、フォーカシング移動量Δの符号は、光線の進行方向を正とする)

(条件対応値)

ｆａ=-113.5000

$fL1=-113.5000$
$fL2=-58.8237$
$\beta a=2.9729$
$\beta b=57.1837$

(1) $(\beta a-\beta a^{-1})^{-2}=0.144$
(2) $\beta a/\beta b=0.052$
(3) $|fa|/(fw\cdot ft)^{1/2}=0.806$
(4) $(\beta b-\beta b^{-1})^{-2}=0.0003$
(5) $fL1/fL2=1.929$
(6) $\nu Ga=60.69$
(7) $nGa=1.74810$

【００５１】図１６乃至図２１は実施例３のｄ線（λ＝５８７．６ｎｍ）に対する諸収差図である。図１６は広角端での無限遠合焦状態における諸収差図であり、図１７は望遠端での無限遠合焦状態における諸収差図である。また、図１８は広角端での撮影倍率－１／３０の合焦状態における諸収差図であり、図１９は望遠端での撮影倍率－１／３０の合焦状態における諸収差図である。さらに、図２０は広角端での撮影距離１．５ｍにおける諸収差図であり、図２１は望遠端での撮影距離１．５ｍにおける諸収差図である。

【００５２】各収差図において、FNOはＦナンバーを、ＮＡは開口数を、Ｙは像高を、Ａは各像高に対する画角を、Ｈは各像高に対する物体高をそれぞれ示している。また、非点収差を示す収差図において実線はサジタル像面を示し、破線はメリディオナル像面を示している。さらに、球面収差を示す収差図において破線はサインコンディション（正弦条件）を示している。各収差図から明らかなように、本実施例では、各焦点距離状態において無限遠合焦状態から近距離合焦状態に亘り諸収差が良好に補正されていることがわかる。

【００５３】

【効果】以上説明したように、本発明によれば、少ない移動量でフォーカシングが可能であり、且つ遠距離物体から近距離物体に対して結像性能の優れた近距離合焦可能なズームレンズを実現することができる。

【図面の簡単な説明】

【図１】近距離物体への合焦を行う際の条件について薄肉レンズ系で説明する図である。

【図２】本発明の第１実施例にかかるズームレンズの屈折力配置図である。

【図３】本発明の第１実施例にかかるズームレンズのレンズ構成を示す図である。

【図４】実施例１の広角端での無限遠合焦状態における諸収差図である。

【図５】実施例１の望遠端での無限遠合焦状態における諸収差図である。

【図６】実施例１の広角端での撮影倍率－１／４０の合焦状態における諸収差図である。

【図７】実施例１の望遠端での撮影倍率－１／４０の合焦状態における諸収差図である。

【図８】本発明の第２実施例にかかるズームレンズの屈折力配置図である。

【図９】本発明の第２実施例にかかるズームレンズのレンズ構成を示す図である。

【図１０】実施例２の広角端での無限遠合焦状態における諸収差図である。

【図１１】実施例２の望遠端での無限遠合焦状態における諸収差図である。

【図１２】実施例２の広角端での撮影倍率－１／３０の合焦状態における諸収差図である。

【図１３】実施例２の望遠端での撮影倍率－１／３０の合焦状態における諸収差図である。

【図１４】本発明の第３実施例にかかるズームレンズの屈折力配置図である。

【図１５】本発明の第３実施例にかかるズームレンズのレンズ構成を示す図である。

【図１６】実施例３の広角端での無限遠合焦状態における諸収差図である。

【図１７】実施例３の望遠端での無限遠合焦状態における諸収差図である。

【図１８】実施例３の広角端での撮影倍率－１／３０の合焦状態における諸収差図である。

【図１９】実施例３の望遠端での撮影倍率－１／３０の合焦状態における諸収差図である。

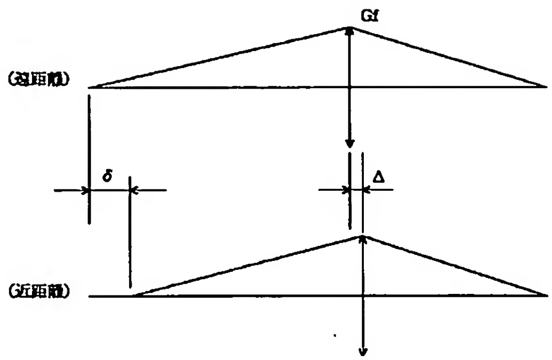
【図２０】実施例３の広角端での撮影距離１．５ｍにおける諸収差図である。

【図２１】実施例３の望遠端での撮影距離１．５ｍにおける諸収差図である。。

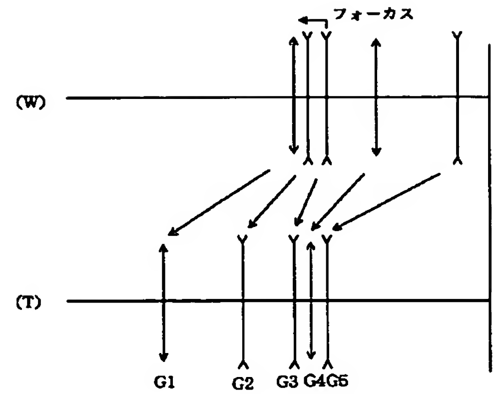
【符号の説明】

Ｇ１　第１レンズ群
Ｇ２　第２レンズ群
Ｇ３　第３レンズ群
Ｇ４　第４レンズ群
Ｇ５　第５レンズ群
Ｓ　開口絞り

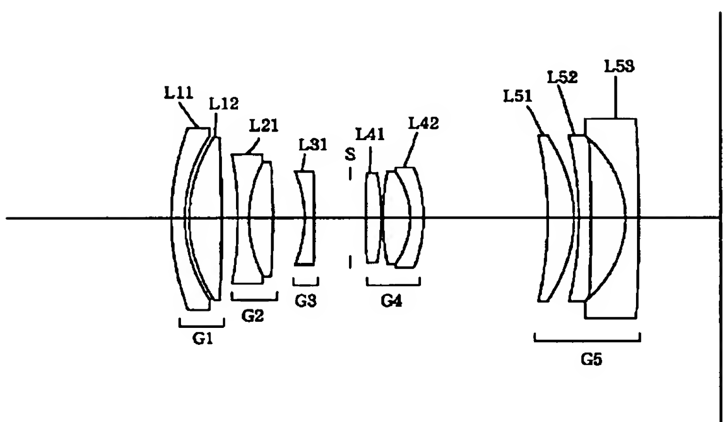
【図１】


Gf
δ
Δ
(近距離)

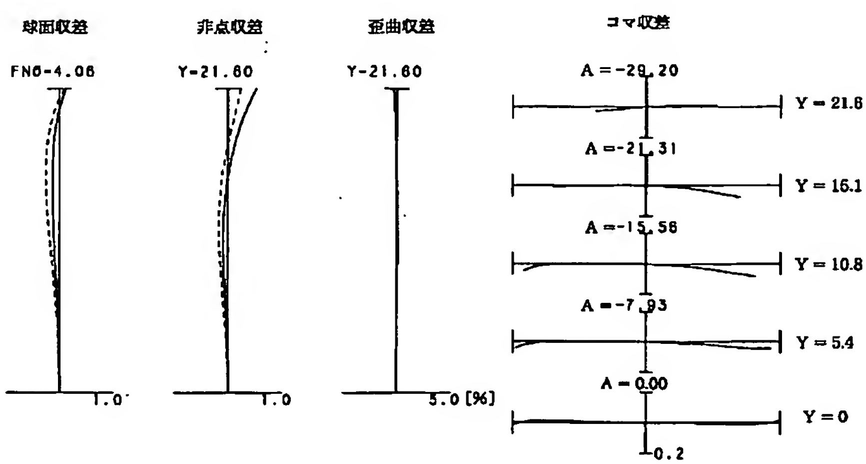
【図２】


フォーカス
(W)
(T)
G1
G2
G3 G4G5

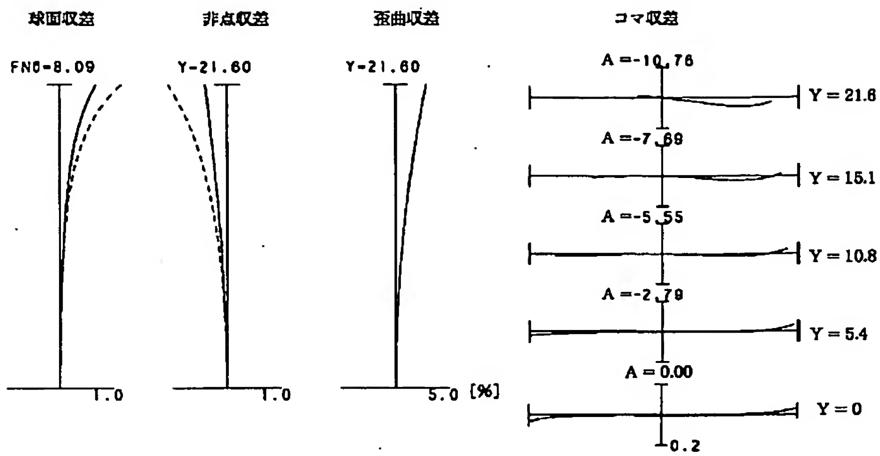
【図３】


L11
L12
L21
L31
S
L41
L42
L51
L52
L53
G1
G2
G3
G4
G5

【図４】

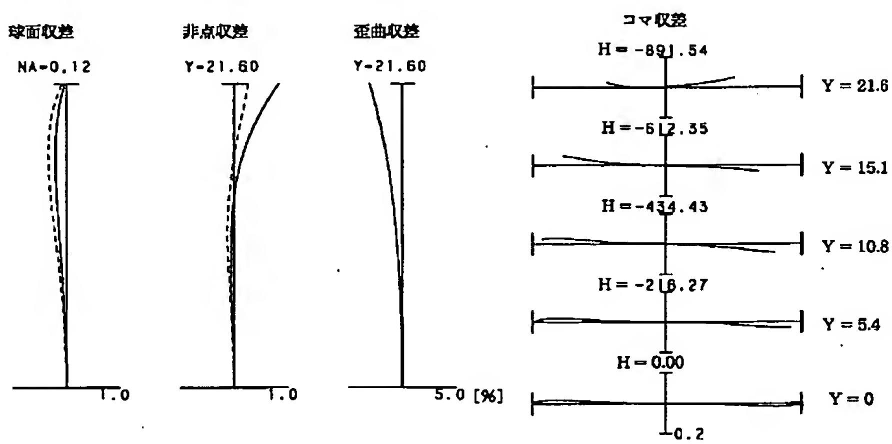

球面収差
非点収差
歪曲収差
コマ収差
FNO=4.06
Y=21.60
Y=21.60
1.0
1.0
5.0 [%]
A = -28.20
Y = 21.6
A = -21.31
Y = 15.1
A = -15.56
Y = 10.8
A = -7.93
Y = 5.4
A = 0.00
Y = 0
0.2

【図5】



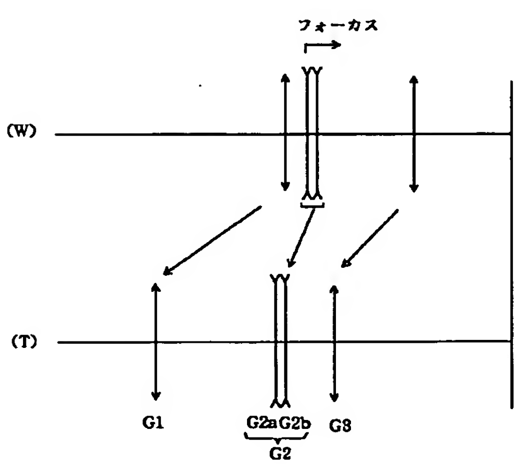
球面収差
非点収差
歪曲収差
コマ収差
FNO=8.09
Y=21.60
Y=21.60
A=-10.76
Y=21.6
A=-7.69
Y=15.1
A=-5.55
Y=10.8
A=-2.79
Y=5.4
A=0.00
Y=0
1.0
1.0
5.0 [%]
0.2

【図6】



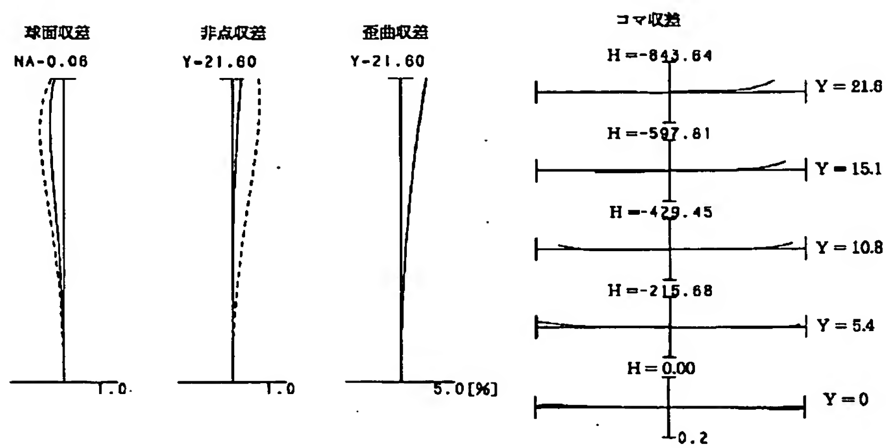
球面収差
非点収差
歪曲収差
コマ収差
NA=0.12
Y=21.60
Y=21.60
H=-891.54
Y=21.6
H=-612.35
Y=15.1
H=-434.43
Y=10.8
H=-216.27
Y=5.4
H=0.00
Y=0
1.0
1.0
5.0 [%]
0.2

【図8】

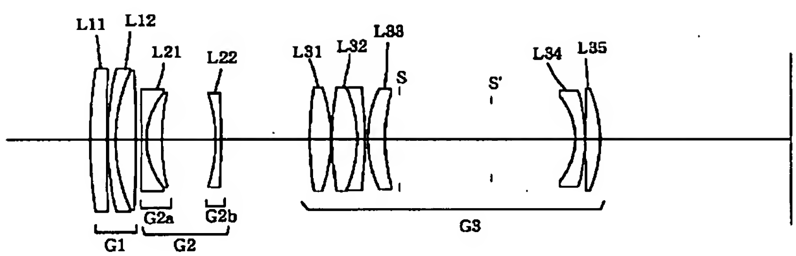


フォーカス
(W)
(T)
G1
G2a G2b
G2
G3

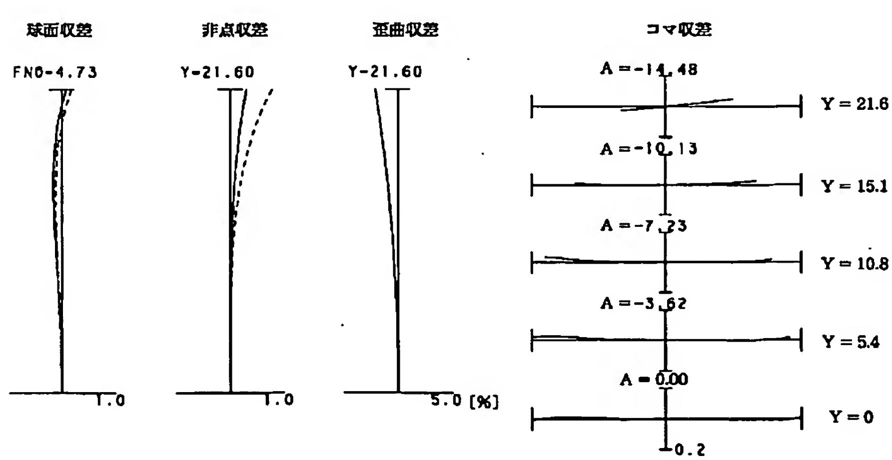
【図７】


球面収差
NA-0.06
1.0
非点収差
Y-21.60
1.0
歪曲収差
Y-21.60
5.0[%]
コマ収差
H=-843.64
Y=21.6
H=-597.81
Y=15.1
H=-429.45
Y=10.8
H=-215.68
Y=5.4
H=0.00
Y=0
0.2

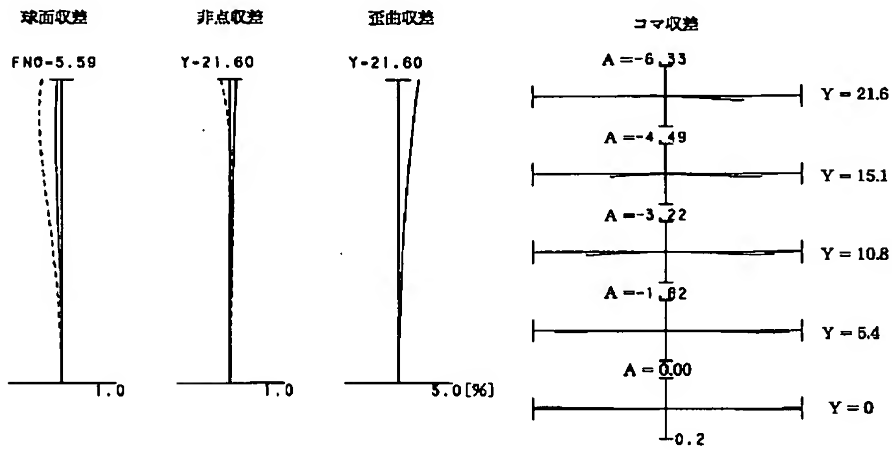
【図９】


L11
L12
L21
L22
L31
L32
L33
S
S'
L34
L35
G2a
G2b
G1
G2
G3

【図１０】

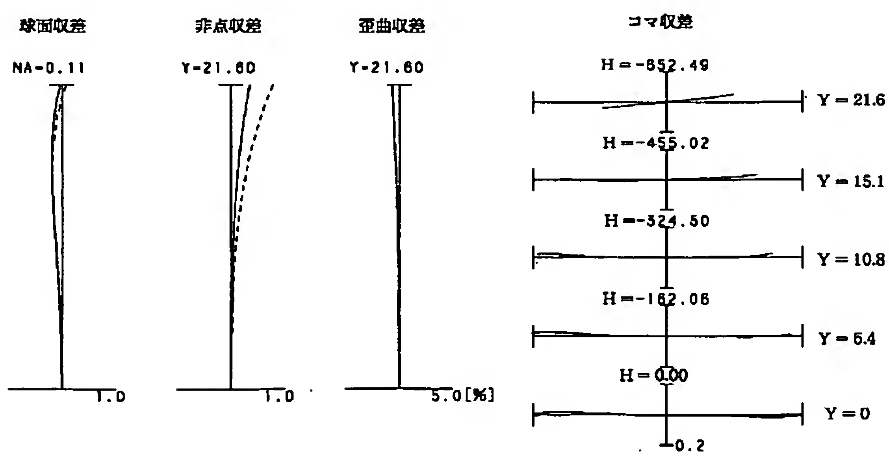

球面収差
FNO-4.73
1.0
非点収差
Y-21.60
1.0
歪曲収差
Y-21.60
5.0 [%]
コマ収差
A=-14.48
Y=21.6
A=-10.13
Y=15.1
A=-7.23
Y=10.8
A=-3.62
Y=5.4
A=0.00
Y=0
0.2

【図11】



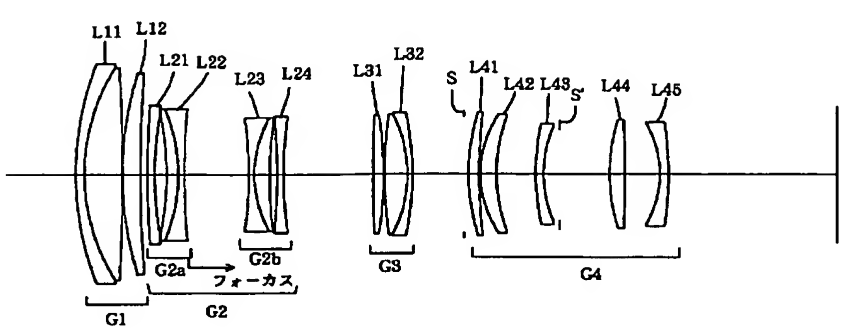
球面収差
非点収差
歪曲収差
コマ収差
FNO=5.59
Y=21.60
Y=21.60
1.0
1.0
5.0[%]
A=-6.33
Y=21.6
A=-4.49
Y=15.1
A=-3.22
Y=10.8
A=-1.62
Y=5.4
A=0.00
Y=0
0.2

【図12】



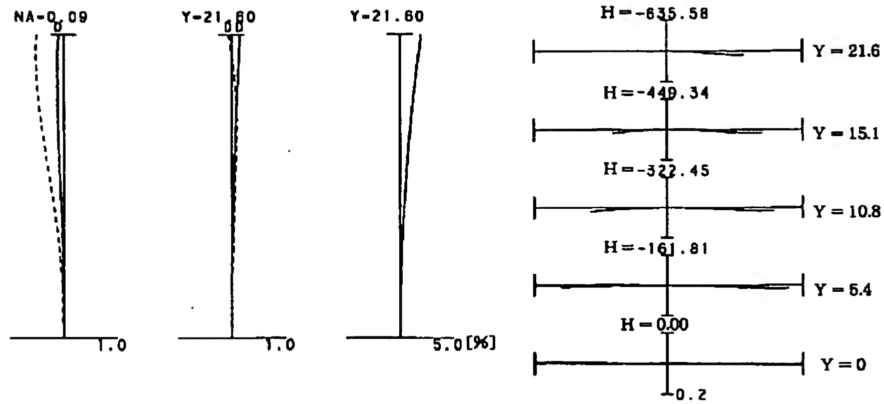
球面収差
非点収差
歪曲収差
コマ収差
NA=0.11
Y=21.60
Y=21.60
1.0
1.0
5.0[%]
H=-652.49
Y=21.6
H=-455.02
Y=15.1
H=-324.50
Y=10.8
H=-162.06
Y=5.4
H=0.00
Y=0
0.2

【図15】

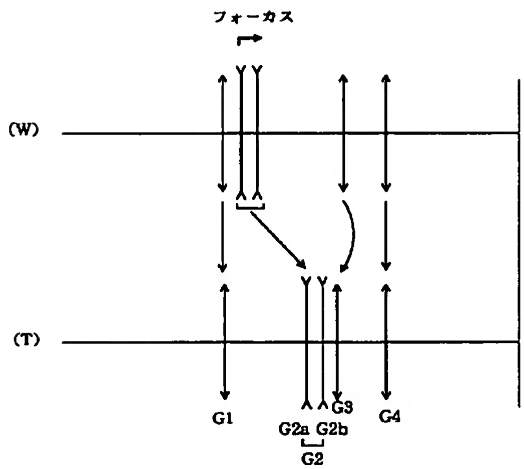


L11
L12
L21
L22
L23
L24
L31
L32
S
L41
L42
L43
S'
L44
L45
G2a
G2b
フォーカス
G3
G4
G1
G2

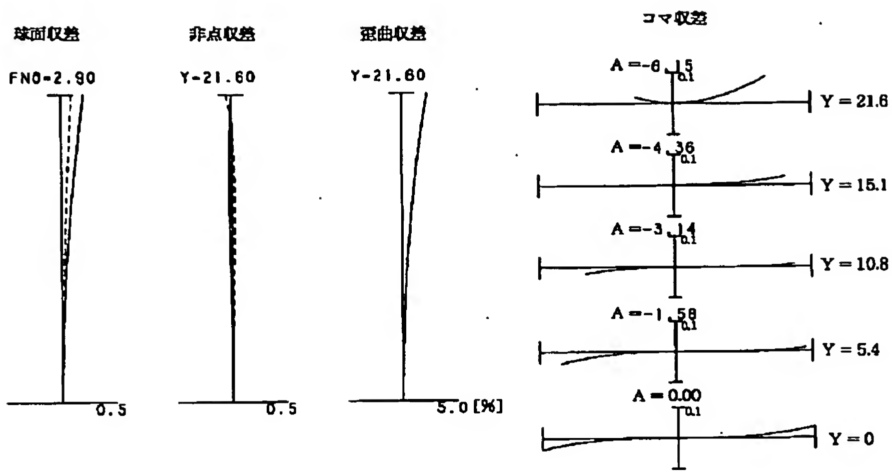
【図１３】


球面収差
非点収差
歪曲収差
コマ収差
NA=0.09
Y=21.60
Y=21.60
H=-635.58
Y=21.6
H=-449.34
Y=15.1
H=-322.45
Y=10.8
H=-161.81
Y=5.4
H=0.00
Y=0
1.0
1.0
5.0[%]
0.2

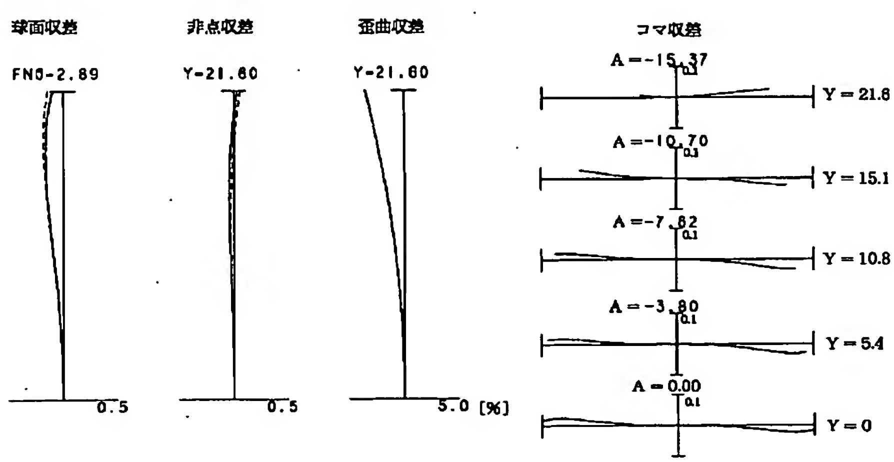
【図１４】


フォーカス
(W)
(T)
G1
G2a
G2b
G2
G3
G4

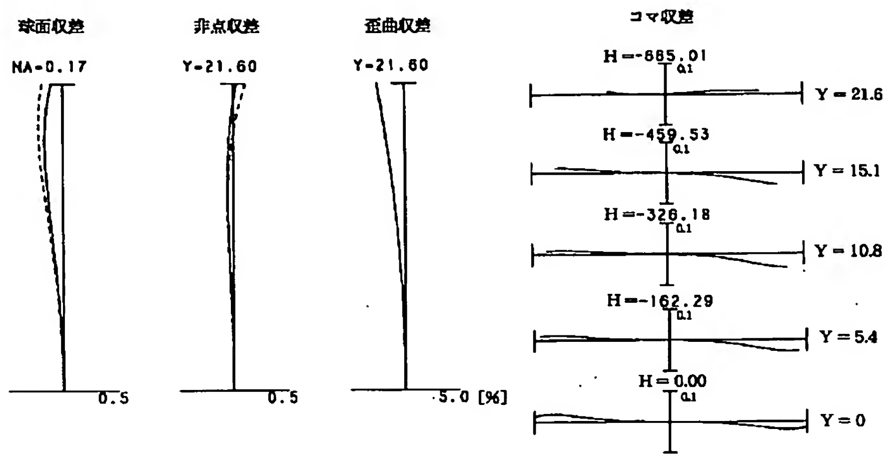
【図16】


球面収差
非点収差
歪曲収差
コマ収差
FNO=2.90
Y=21.60
Y=21.60
0.5
0.5
5.0 [%]
A=-6.15
Y=21.6
A=-4.36
Y=15.1
A=-3.14
Y=10.8
A=-1.58
Y=5.4
A=0.00
Y=0
0.1

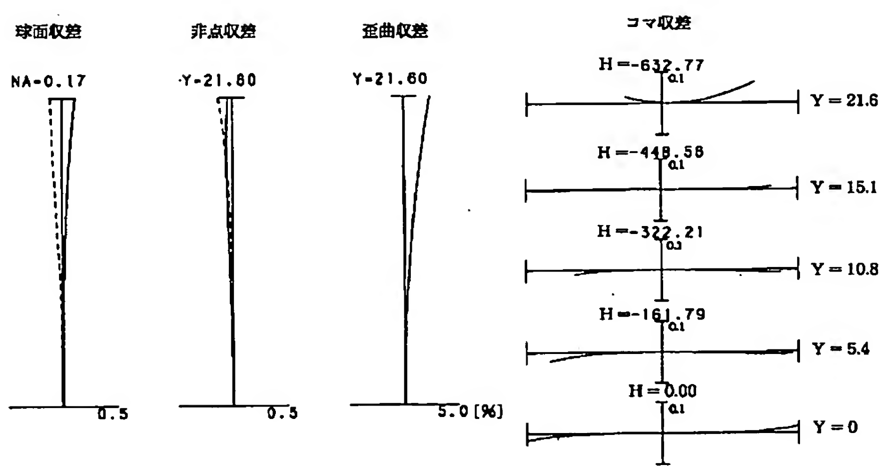
【図17】


球面収差
非点収差
歪曲収差
コマ収差
FNO=2.89
Y=21.60
Y=21.60
0.5
0.5
5.0 [%]
A=-15.37
Y=21.6
A=-10.70
Y=15.1
A=-7.62
Y=10.8
A=-3.80
Y=5.4
A=0.00
Y=0
0.1

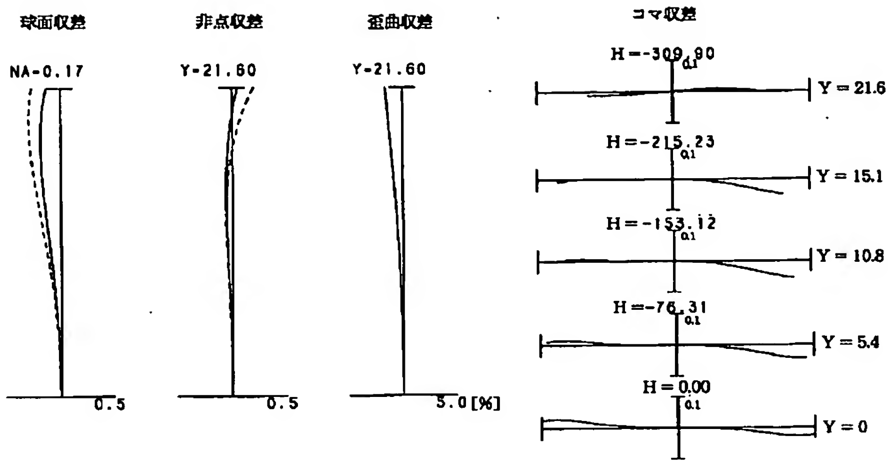
【図１８】


球面収差
非点収差
歪曲収差
コマ収差
NA=0.17
Y=21.60
Y=21.60
0.5
0.5
5.0 [%]
H=-685.01
Y=21.6
H=-459.53
Y=15.1
H=-326.18
Y=10.8
H=-162.29
Y=5.4
H=0.00
Y=0
0.1

【図１９】

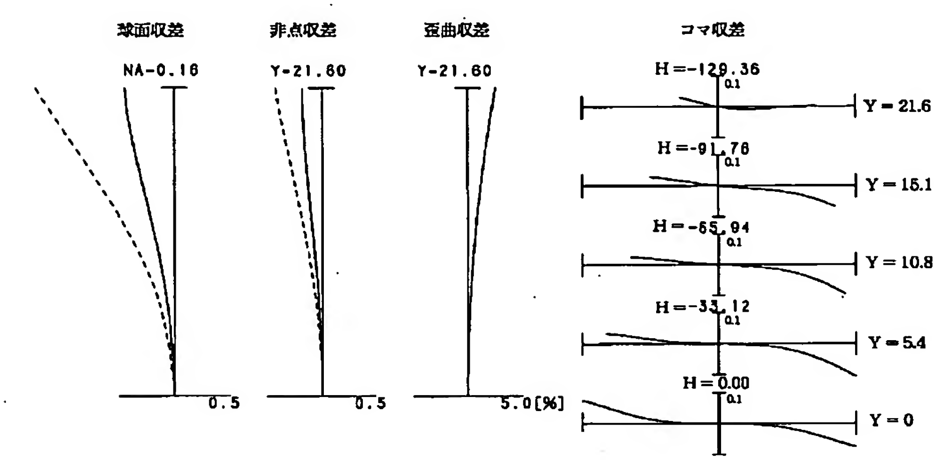

球面収差
非点収差
歪曲収差
コマ収差
NA=0.17
Y=21.60
Y=21.60
0.5
0.5
5.0 [%]
H=-632.77
Y=21.6
H=-448.58
Y=15.1
H=-322.21
Y=10.8
H=-161.79
Y=5.4
H=0.00
Y=0
0.1

【図２０】



球面収差
非点収差
歪曲収差
コマ収差
NA-0.17
Y-21.60
Y-21.60
H=-309.90
Y=21.6
H=-215.23
Y=15.1
H=-153.12
Y=10.8
H=-76.31
Y=5.4
H=0.00
Y=0
0.1
0.5
0.5
5.0[%]

【図２１】



球面収差
非点収差
歪曲収差
コマ収差
NA-0.16
Y-21.60
Y-21.60
H=-129.36
Y=21.6
H=-91.76
Y=15.1
H=-65.94
Y=10.8
H=-33.12
Y=5.4
H=0.00
Y=0
0.1
0.5
0.5
5.0[%]